U. S. Bureau of Ent...

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 21.

REPORT

OF A

TRIP TO AUSTRALIA

TO INVESTIGATE THE

NATURAL ENEMIES OF THE FLUTED SCALE,

BY

ALBERT KOEBELE.

(MADE UNDER DIRECTION OF THE ENTOMOLOGIST.)

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LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY,
Washington, D. C., November 22, 1889.

SIR: I have the honor to submit for publication Bulletin No. 21 of this Division, being the report of Mr. Albert Koebele upon the Fluted Scale (*Icerya purchasi* Maskell) and its natural enemies in Australia. I had intended to incorporate it in my forthcoming annual report, but the limited space alloted to that report makes it necessary to publish this as a separate bulletin.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The following report by Mr. Albert Koebele, one of the California agents of the Division of Entomology, gives an account of his trip to Australia, made during the late summer and fall of 1888 and the winter of 1888–'89, under instructions from this Department, for the purpose of investigating the Australian natural enemies of the Fluted Scale (*Icerya purchasi* Maskell) with a view to introducing the most efficient of them into California.

Failing to secure a specific appropriation from Congress for this purpose, although assisted in the attempt by the California delegation, and particularly by the Hon. C. M. Felton, and failing also to secure the removal of the clause restricting travel to the limits of the United States, we were led to accomplish the result through the kindness of the Department of State, in connection with the Melbourne Exposition, an arrangement having been made whereby two of the salaried agents of the Division should be temporarily attached to the Commission, their expenses, outside the United States, to be defrayed by the Commission, within the sum of $2,000. The warm thanks of this Department are due to the Department of State for this coöperation, and particularly to the Hon. Frank McCoppin, commissioner-general to the Exposition, to whom the matter was submitted by the State Department for approval. Mr. McCoppin at once accepted the proposition, and upon Mr. Koebele's arrival in Australia helped him in every way possible to make the experiment successful.

Mr. Koebele was sent, as just stated, for the specific purpose of studying and importing the natural enemies of the Fluted Scale, while the other agent, Mr. F. M. Webster, was sent to make a special report to the Commission on the agricultural features of the Exposition. Mr. Webster's report has been sent to the Commission, and was formally submitted to Mr. McCoppin. A copy of the present report, although purely entomological, and having little relation to the Exposition proper, has also been transmitted to Mr. McCoppin, as the results of the mission are, and ever will be, connected with his exposition work.

While a number of other entomological matters are referred to in the report, Mr. Koebele never lost sight of the main object of his mission. How successful it has proved late reports already published in INSECT

LIFE, and elsewhere, have abundantly testified. They have more than justified the anticipations expressed in my last annual report:

We fully expect to learn of the increase and rapid spread of this new introduction as well as some of the other predaceous species which have been introduced, and to find that in a comparatively few years the orange groves of southern California will be kept measurably freed of the pernicious Fluted Scale without so great an effort on the part of the growers or so great expense in destroying it. That nature will, with the new conditions induced by these importations, come to the relief of the fruit-grower, and that this interesting experiment will result in the ultimate saving of untold millions to the people of the Pacific Coast is our sincere belief which we hope to see verified. Not that we expect the Icerya to be ever entirely exterminated; but it will be kept under subjection so as to be comparatively harmless, as it is in its native country.

One of the insects imported, viz, the Cardinal Vedalia (*Vedalia cardinalis* Mulsant), has multiplied and increased to such an extent as to rid many of the orange groves from Icerya and to promise immunity in the near future for the entire State of California. In fact, the rapid multiplication and the effective work of this little beetle are almost incomprehensible until we come to consider its power of increase in a climate like that of southern California, where there is scarcely any cessation in its activities.

A careful account of the transformations of the Vedalia has been prepared by Mr. Coquillett and was published in INSECT LIFE for September, 1889, pages 70 to 74. I reproduce the figures in connection with Mr. Koebele's report in order to familiarize those who have not yet seen it with its appearance. I have also had some other figures made to accompany the report.

The period from the laying of the eggs until the adults again appear occupies less than thirty days for the Vedalia. At this rate of increase, calculating that three hundred eggs are laid by each female, and that one half of these produce females, it will readily be seen that in six months the offspring of a single female beetle may under favorable circumstances amount to over twenty-two trillions. So far it has not been noticed to prey upon any other insect than the Fluted Scale, a fact which accounts somewhat for its exceptionally rapid work and renders the outlook extremely encouraging.

Of the other enemies of the Icerya referred to and more particularly mentioned in the latter part of Mr. Koebele's report, none of them have so far given much promise, and there is risk of their not being colonized by virtue of the extraordinary spread and increase of the Vedalia, which has swept away from whole regions the Fluted Scale, upon which they depend. This contingency should have been avoided and I very much regret that they have not become established in California, because their establishment, and especially that of the little Dipteron, *Cryptochætum iceryæ*, would have helped in the general subjection of the pest and would be particularly valuable whenever the Vedalia, for whatever reason, at any time practically forsakes a given locality.

C. V. R.

LETTER OF SUBMITTAL.

ALAMEDA, CAL., *July* 17, 1889

SIR: I herewith submit my report upon the study of *Icerya purchasi* in Australia and New Zealand and the introduction of its parasites and enemies into California, undertaken under your direction and in accordance with your letter of instructions.*

Respectfully yours,

ALBERT KOEBELE,
Special Agent.

Prof. V. C. RILEY,
U. S. Entomologist.

*The following is extracted from the letter of instructions:

WASHINGTON, *July* 3, 1888.

* * * As you are already aware you are sent to Australia for the purpose of making an investigation of the parasites and other natural enemies of *Icerya purchasi* with a view of introducing them into California. It will be necessary for you to go to Adelaide to see Mr. Frazer S. Crawford, who sent over the first Dipterous parasites and the *Cœlostomas* (or rather *Monophlœbus crawfordi*). This Dipterous parasite has been named by Dr. Williston *Lestophonus iceryæ*, and at Adelaide you will probably be able to study this insect carefully. Make the most careful investigations where you can learn of the occurrence of *Icerya* and find all of its natural enemies in Australia. Find out also the periods at which these parasites oviposit and ascertain the season at which success in importation will be most likely with each and all of them. Once on the ground you can see for yourself just what will be necessary to be done in order to bring about this result. You should also endeavor to place the Department in correspondence with as many observers as you can interest in the subject, and should by all means endeavor to get at least one man who will be able to devote some time to the matter and continue observations after you leave. It is barely possible that we may be able to re-imburse some such person for the time expended, but for this I will write you later, if indeed I do not see you personally in Australia in November. You will, of course, inquire immediately upon arriving in Melbourne concerning the largest orange-growing districts in Australia, and also make inquiries as to the best places for observing *Icerya*, aside from Adelaide. If you will visit the Botanic Gardens in Melbourne you will be able to get some information there. Baron von Mueller, formerly director of the Botanic Gardens, is still a resident of that city and you will find him a very well-informed person to consult. I inclose you letters of introduction both to Mr. Crawford and Baron von Mueller. * * *

On this trip your salary will be paid as usual by this Department, but your expenses by the Department of State through Mr. McCoppin. * * *

REPORT OF THE FLUTED SCALE OF THE ORANGE AND ITS NATURAL ENEMIES IN AUSTRALIA.

By Albert Koebele.

In accordance with the commission received from the Hon. Norman J. Colman, United States Commissioner of Agriculture, and your letter of July 3, 1888, I left San Francisco on August 25, and arrived at Auckland, New Zealand, on September 14, where some hours were spent in getting information in regard to Icerya. I visited Mr. W. Will, editor of the *New Zealand Herald* and *Auckland Weekly News*, who then, and subsequently on my later visit, gave me valuable information in regard to the occurrence and disappearance of Icerya in the Auckland districts, as well as many other points of interest in horticulture; and also Mr. T. F. Cheeseman, curator of the Auckland Museum, who readily accompanied me to a place full of *Albizzia* (*Acacia*) *lophantha*, Bentham, which had been about three years previously completely covered with Icerya. I made a careful search for specimens on these trees, yet only four full-grown females with large egg-sacs could be found. On one of the scales two rather large mites were feeding, attached to the under side; and the masses of old and moldy remains of Icerya were still visible on the trunks of trees.

A residence on which formerly were many orange trees was also visited. There all of the trees had been cut down on account of the numerous scales, and at the time of my visit no Icerya could be found and none were observed during the year as the proprietors informed me. No one was able to state the exact reason of the disappearance of the scales; some disease was the supposed cause.

The steamer left Auckland the following day and arrived in Sydney, New South Wales, September 20. I remained there for four days in search of Icerya. On my first walk a number of them were discovered at the town hall premises, infesting a Pittosporum (*P. undulatum*), and the succeeding days a few more were found in one of the public parks, also on this Pittosporum. A large isolated acacia tree full of the scales was found in front of a private house in the eastern part of Sydney; all were full-grown females with more or less developed egg-sacs and ap-

parently in a healthy condition. As the trees infested were all inclosed, no proper examination could be made and the few obtained at the town hall showed no trace of parasites. A trip was also made to Parramatta, about 14 miles to the west of Sydney, to look into some of the orange orchards. I found nearly all the trees badly infested with the red-scale (*Aspidiotus aurantii* Maskell, Fig. 1), and still worse with what I con-

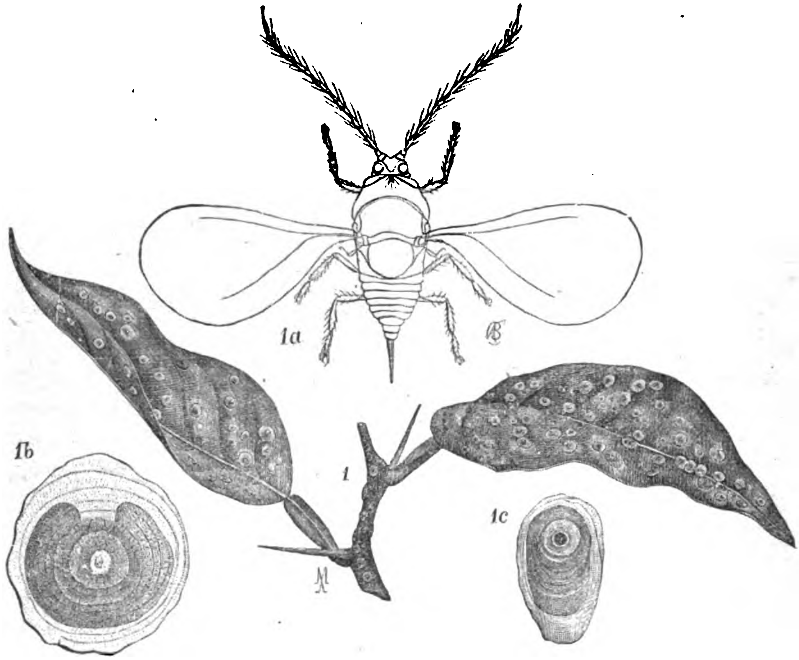


Fig. 1.—*Aspidiotus aurantii* Maskell: 1, scales on leaf of orange, natural size; 1*a*, adult male; 1*b*, scales of female; 1*c*, scale of male—enlarged (after Comstock).

sidered to be *Mytilaspis gloverii* Packard.* Indeed, some of the trees are completely covered by this latter scale, having the appearance of an old coat of whitewash on the bark which had partly fallen off. None of the several orange-growers there visited had ever seen an Icerya or was familiar with the insect. I left Sydney on the 24th and arrived in Melbourne the following day, having in the meantime, through the kindness of the United States consul, obtained a free pass over the New South Wales Railway, which courtesy was shown me by all the colonies subsequently visited. Indeed, I can not speak too highly of the kindness shown me by all the Government officials, and of the interest they took in the successful execution of my work. I remained in Melbourne for six days, during which time I visited Baron Ferdinand von Mueller, to whom you had given me letters of introduction. This gentleman assured me that the Icerya never became extensively injurious in Aus-

*A careful study of the pygidial characters of this scale shows it to be much nearer *M. pomorum* than *M. gloverii*. It seems, however, to be distinct from the former and will probably prove to be new.—C. V. R.

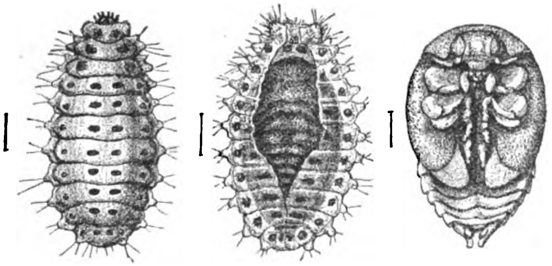
tralia. Occasionally and in certain spots they became numerous, but always disappeared again. I also met Mr. C. French, Baron von Mueller's assistant, who has had some experience in entomology. He claims that the scale has been known to him for thirty-four years, yet he has never seen it in large numbers.

At the Zoological Gardens I found on a species of Eucalyptus a coccid in such numbers as to cover the under side of all the larger branches and the stem in part. Many of the winged males were secreted among the crevices of bark, with their two long white setous hairs protruding. Numerous larvæ of a coleopter were found under chips of bark feeding upon the scales, apparently belonging to some clerid. I never met with these larvæ again in my later researches nor with the coccid mentioned. A great variety of scales was observed at Melbourne; the most pernicious amongst them, a species of *Aspidiotus*, deserved attention. This is *A. rossi* Crawford, figured on his plate 18 of the Coccidæ, but as yet no description has appeared to my knowledge. I have seen olive trees completely covered by this scale; it will attack almost any kind of tree or shrub as I later observed. Many of the shrubs in the Botanical Gardens in Melbourne infested by this scale were in a dying condition. The introduction of this pest would be of serious consequence to the United States and we should be on our guard against this as well as a second species of waxy scale, probably a species of *Ceroplastes*. This last is covered by a thick, smooth, white, waxy matter which effectually protects it. Nothing would destroy this scale, except remedies against the newly hatched larvæ, which, before they exude any wax, are easily killed. The insect was observed all over eastern Australia, and it was numerous in the Botanical Garden at Sydney and in the woods near Brisbane. At the Botanical Gardens they could find no remedy except cutting down the infested plants. I recommended a strong resin wash for the newly hatched larvæ. No Icerya could be found during my short stay at Melbourne.

I arrived at Adelaide, South Australia, on October 2, with letters of introduction to Mr. Frazer S. Crawford, of the surveyor general's office, who received me very kindly and promised me his assistance, which promise he honorably fulfilled throughout my stay in Adelaide. I saw the man who discovered the parasites of Icerya (*Lestophonus iceryæ*), and, indeed, felt very happy when he promised to show me a large colony of the scales on the following day. Early the next morning Mr. A. Molineux, agricultural editor of the *South Australian Register and Adelaide Observer*, and proprietor of the *Garden and Field*, showed me about a dozen orange and lemon trees in a private garden in the suburbs of Adelaide all more or less infested with Icerya, and had been so for the previous two years. The scales were nearly all full grown, or rather nearly all of them had begun to exude cottony matter and deposit eggs, yet they were not quite so far advanced as those observed at Sydney.

The very first scale examined contained nine pupæ of the parasitic fly, *Lestophonus*, and the scale was still living. Nearly all of the many

others examined proved to have either larvæ or puparia within them; none of the flies had at that time made their appearance. I attended the gardeners' meeting at Adelaide on October 6, in order to get information as to the occurrence of Icerya, yet but very few of the gentlemen were acquainted with the insect. To show how rare Icerya is in South Australia, Mr. J. G. O. Tepper, of the museum at Adelaide, a qualified entomologist, who has collected insects all his life, has known Icerya only for the last two years. He never met before this with any specimens in all his collecting trips through South Australia. On October 15 I made a trip with Messrs. Crawford and Tepper to North Adelaide, where some Icerya were said to exist; we found there in one garden a few orange and lemon trees with the scales, which were subsequently collected for shipment. In another garden, and also on orange, an oc-



a b c

FIG. 2.—*Vedalia cardinalis*: *a*, full grown larva; *b*, pupa, dorsal view, inclosed in last larval skin; *c*, pupa, naked, ventral view—all enlarged (after Riley).

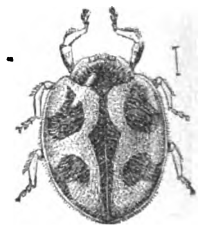


FIG. 3.—*Vedalia cardinalis*, adult—enlarged (after Riley).

casional specimen was found. I discovered there, for the first time, feeding upon a large female Icerya, the Lady-bird, which will become famed in the United States—*Vedalia cardinalis* (Figs. 2 and 3). I called the attention of both the gentlemen to this insect, yet neither of them had ever seen it nor knew the beetle. Mr. Tepper has charge of a large collection of insects, and especially of Coleoptera, at the South Australian Museum. Mr. Smith, the proprietor of the nursery, also called my attention to a beetle, a curculio, which is very destructive to olive-trees, eating the young shoots and leaves of the plants during the night and secreting itself in the ground during the day-time (Fig. 4).*

FIG. 4.—Olive Snout-beetle—enlarged (original).

Through the bureau of forestry at Adelaide I was informed that a colony of Icerya existed at Mannum, on the Murray River, and a trip to that place was made on October 18. In two gardens Icerya was present; in one of them they existed on only a few of the many orange-trees, and none examined showed any parasites, while in the other on two

* This is an Otiorhynchid unknown to us, and will have to be referred to a specialist abroad.—C. V. R.

trees that were infested many of the scales were parasitized. In addition to the parasites, numerous larvæ and eggs of a lace-winged fly (*Chrysopa*) were observed, the larvæ preying upon the scales and chiefly upon their eggs. They were covered so much with the cottony matter of Icerya as to resemble this insect very closely, and were difficult to pick out from the torn masses of egg-sacs. I also observed here a coleopterous (*Coccinellid*) larva, seen before at Adelaide, feeding on the scales, and this proved to be that of the Vedalia. All the scales here, as well as all the predaceous larvæ found feeding upon them, were collected and taken to Adelaide to be shipped to California, together with those found at the latter place. They were kept boxed in a cool cellar. The scales in Adelaide and suburbs were collected on October 24 and 25 at a place in North Adelaide. Nearly every one of the Iceryas exposed to light and sun contained parasites, and many of these had already left, as numerous holes were visible. Of the scales found on a small and bushy mandarin tree, where they were excluded from the sun, only a few contained parasites, but the larvæ of the *Chrysopa* were abundant. Most of the larger egg-sacs of Icerya were torn by them and the contents devoured.

I observed also that many of the young scales, only sufficiently large to contain a single puparium of the fly, were infested, the expanded skin of Icerya forming a thin covering over the puparium of the *Lestophonus*. This was observed at all places where Icerya occurred. No doubt the eggs of the pest must be deposited while the scales are yet quite small, probably even before the first molt, and certainly later, as the scales will go on feeding and increasing in size until the larvæ within them pupate. At this time large numbers of the scales were hatching and also of the flies. Only one living fly was observed on October 24 while collecting the scales, sitting between two large egg-masses and hardly visible to the eye. This and a second specimen taken under similar circumstances were the only ones I observed in nature. I have never met with a single specimen depositing eggs or even sitting on an Icerya nor flying around. I finished collecting for my first shipment on the 25th and estimated that I had about 6,000 Icerya, which in return would produce at an average about four parasites (*Lestophonus*) each. They were packed partly in wooden and partly in tin boxes. Small branches generally full of scales were cut so as to fit exactly lengthwise into the box. With these the boxes were filled and all loose scales placed in between, plenty of space remaining for any of the insects within to move about freely without danger of being crushed by loose sticks. Salicylic acid was used in small quantities in the tin boxes to prevent mold, yet these, as I have been informed by Mr. Coquillett, arrived in a more or less moldy condition, while those in wooden boxes always arrived safe. In addition, Dr. Schomburgh, director of the botanical gardens at Adelaide, kindly fitted up for me a Wardian case which was filled with living plants of oranges and *Pit-*

tosporum in pots. Large numbers of Icerya were placed in this, and such larvæ as were found feeding upon them, including some of a *Scymnus** (Fig. 5), only occasionally found with Icerya, yet very abundant on various Eucalyptus scales, especially on *Eriococcus eucalypti.* Of this I sent large numbers to California in my later shipments, as they were easily collected by the hundreds under bark of Eucalyptus infested with this *Eriococcus.* Mr. F. M. Webster brought me the same insect in numbers from Tasmania, together with the *Eriococcus* on Eucalyptus. The object of this was to have the *Lestophonus* go on breeding within the case during the voyage. No doubt many infested scales arrived in Los Angeles.

FIG. 5.—*Scymnus restitutor*—enlarged (original).

I found on examining the tree, on April 12, 1889, under which this case had been placed with a tent over it, that from several of the Iceryas the *Lestophonus* had issued. This case, as Mr. Coquillett informed me in letter of November 30, arrived in good condition, except that the putty had been knocked off in several places, leaving holes large enough for the parasites to escape. Before opening the case he found two coccinellid larvæ crawling on the outside, and these when placed with the Icerya attacked it at once. He further said that there were only about half a dozen living *Chrysopa* adults. This would show that the *Lestophonus* was still issuing on arrival in California and all turned out more favorably than I had anticipated on seeing the box handled in such a rough manner by the steamer hands at Sydney, to which point I accompanied this as well as all the subsequent shipments. I expected little good would come out of this method of sending and therefore concluded to send only small parcels on ice thereafter, as had been partly done at first. If once the insects could be placed in good condition in the ice-house on the steamer just before leaving, where a temperature of 38° Fah. at first and about 46° Fah. on arrival in San Francisco existed, they must arrive safely. To accomplish this, the parasites with their hosts were all collected the last three days before leaving Adelaide, and on arriving home were immediately placed in a cool cellar. On the trip from Adelaide to Sydney, which takes two days by train, my insects came generally in an ice-box on the sleeping-car.

On November 2 I made a trip to Gordon, 11 miles north of Sydney, Mr. James Harold, agricultural reporter of the *Town and Country Journal,* Sydney, having furnished me with the address of a prominent fruit-grower there. Mr. Harold has traveled much over Australia gathering information for his paper, yet, as he assured me, he never met with an Icerya. The same answer was received from the gentleman at Gordon, who has been living in the colony for thirty-four years and has raised oranges for thirty-two years. He knew only the three scales upon

* Dr. Sharp has since described this as *Scymnus restitutor* (Insect Life, I, 364).

oranges, viz: *Lecanium oleæ* (Fig. 6) and the *Mytilaspis* and *Aspidiotus aurantii.* This latter is not doing any serious damage to his trees, providing they are well taken care of, yet he assured me that in some parts of the colony it is impossible to raise oranges on account of the ravages of this scale. For the *Mytilaspis* he uses sulphur and lime as a wash, applying it with a paint brush. This he claims need only be repeated every three years, as during this time the trees remain comparatively free. The mixture is prepared in the following way:

Unslacked lime, two parts; sulphur, one part; water is poured on this in sufficient quantities to boil and unite with it. It is applied as a white-wash to the trees and to prevent injury should not be too strong

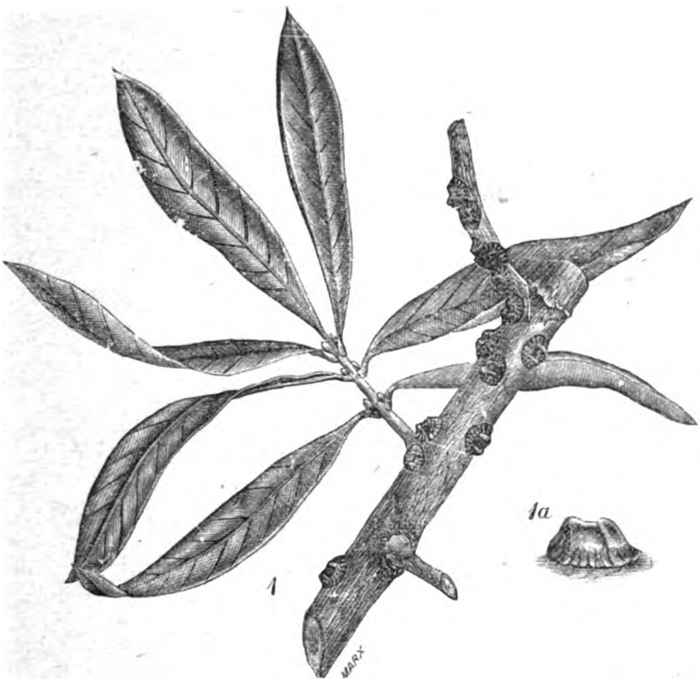


FIG. 6.—*Lecanium oleæ:* 1, adult females on olive leaves—natural size; 1a, female—enlarged (after Comstock).

Besides the scales, an Aphis appears occasionally on orange and peach trees. Two beetles are numerous and destructive to the melon vines here. One of them found at the time is a *Diabrotica*, often received by Mr. Crawford, of Adelaide, as doing great injury to the melon tribe. This gentleman, however, claims that all injury can be avoided by dusting powdered lime over the plants. The beetles, he said, will not attack leaves thus treated. I found here, as well as all over Australia and New Zealand, the Woolly-Aphis (*Schizoneura lanigera*), yet they could be seen only on the branches, as all or nearly all the apples raised in the colonies and New Zealand are said to be grafted on blight-proof

stock. For this purpose, the Northern Spy of our continent is considered the best; next comes the Majetin, as Mr. Will, of Auckland, informed me. The Irish peach was standing completely free of Aphis between badly infested trees. A large number of blight-proof trees are sold by nurserymen in Australia and New Zealand, and only such are planted in these countries as far as the roots are concerned. Mr. Will said that the Northern Spy will produce the best roots; on this is grafted the Majetin as the stem, and any desired variety may be selected for the upper part or branches. At this place I observed a small black and lemon-yellow lady-bird (Fig. 7) feeding upon the Woolly-Aphis; the same was also observed at Toowoomba, Queensland, under similar circumstances.* I did not meet with it outside of these places. No Icerya could be found on the orange trees, but the same day, two young specimens were found in the woods, about 2 miles distant, one of them on a pea-vine and the second on a species of *Salix*, both near the ground.

FIG. 7.—Lady-bird feeding on Woolly Aphis—enlarged (original).

November 5 I visited Mr. Joseph Purser at Castle Hill, to the west of Sydney, also a prominent fruit-grower. No Icerya were found on the numerous orange trees at this place. Mr. Purser reports having met with an occasional specimen only on his orange trees, never more than half a dozen. A short distance from the orchard I noticed a small pond on the edge of which were growing a few small bushes of Acacia. On examination I found two large Iceryas with egg sacs and several empty skins of scales. Mr. Purser informed me that in former years he has often seen the scales upon trees growing along river banks. During this same day, while searching through the bush, I found upon the needle-bush *Hakia acicularis*, growing amongst numerous *Acacia longifolia*, a well developed Icerya fastened to the main stem. A careful search was made on all the plants growing there, yet with the exception of a peculiar Cœlostoma upon Acacia, no scales could be found. One specimen of Icerya was found on this Acacia at the botanical gardens in Adelaide. Mr. Purser, who is also much troubled with the *Mytilaspis* mentioned, used as a remedy kerosene-tar, 1 pint; soft-soap, 3 pounds; sulphur, 5 pounds. These are boiled in 10 gallons of water and the trees washed with this mixture with a paint-brush, only the trunk and larger limbs being treated. The gentleman claims that all the scales on trees so treated will be killed and the trees will remain free from scales from seven to nine years.

I returned to Adelaide on November 8, as I considered that the best field to obtain the material. On the 15th a trip was made about 300 miles north of Adelaide, but I found nothing of interest in the insect line on this journey, with the exception along the road of large num-

* This species has been sent abroad for determination.—C. V. R.

bers of locusts traveling south in search of food, nothing being left for them in the interior to feed upon. The country around Quorn was so dry and hot that some *Eucalyptus rostrata* in a dry river-bed were all the green vegetation that could be seen, and the locusts still met with were unable to feed. Finding the search for Icerya in this district useless, I returned to Adelaide, where subsequently new colonies were discovered for shipment. In conversation about the grasshoppers en route, a gentleman remarked that only in such unusually dry seasons as the present would the locusts migrate, there being no food left for them in the interior of South Australia. Those around Quorn, he remarked, left in a southeasterly direction down the valley toward Adelaide, while those coming from the interior went towards Spencer's Gulf. On my trip I observed them most abundantly about Black Rock traveling south, not in clouds but scattered and never very high, similar to our *Caloptenus devastator* in California in 1885.*

November 29 I began collecting material for my second shipment. Already on some of the trees, well exposed to sun, about 90 per cent. of the flies had left the scales, while on the trees in more shady places more than half of the parasites were still within their hosts. Not a single fly was observed, and yet they must have been about in large numbers. Instead of this, I noticed sitting and walking about the scales a peculiar Chalcid † (Fig. 8); this was suspected to be a secondary

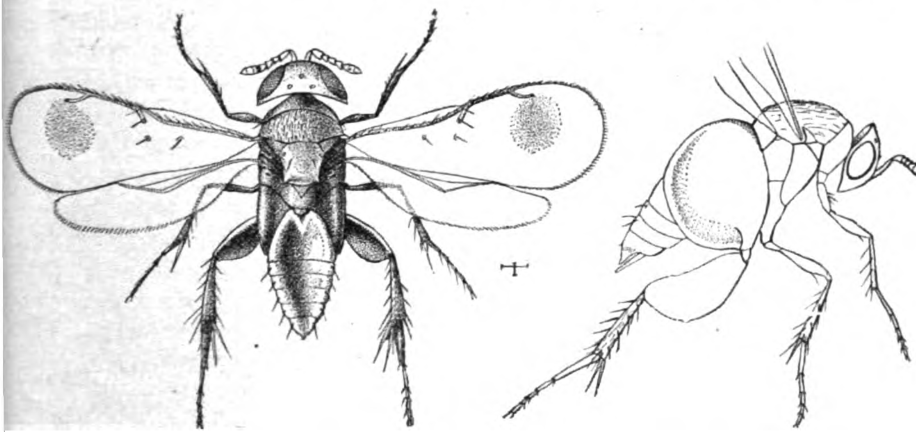


FIG. 8.—*Euryischia lestophoni*, dorsal and side views—enlarged (after Riley.)

parasite, and during the day I noticed them ovipositing in the infested Iceryas. The Lady-birds were at that time quite abundant in egg, larva, pupa, and imago states, and special pains were taken not to miss any of these during the collecting. The following four days were

* We have sent specimens of this locust to M. Henri de Saussure, of Geneva, Switzerland, for determination, but at the date of going to press have not received his reply.—C. V. R.

† This is the species referred to in our annual report for 1888, p. 92, under the MS. name *Euryischia lestophoni*.—C. V. R.

spent in gathering Icerya and its enemies. Many of the secondary parasites were again noticed, yet not a single *Lestophonus*. I gathered during this time probably six thousand scales, and hardly a specimen was noticed among them that was not parasitized by the *Lestophonus*. All of them contained either puparia of the fly or empty holes where the flies had issued. Knowing that if we should introduce the secondary parasite the good work of *Lestophonus* on Icerya would be greatly restricted, I sent the following notice to Mr. Coquillett, and also to your office.

On account of a parasite of *Lestophonus iceryæ*, remove the infested scales that I send from the tree they were placed on, after six weeks, and transfer into large glass jars; examine daily by stupefying the insects that have issued, with chloroform or ether, empty contents on table, pick out the flies and destroy their parasites. Form a new colony with every consignment you receive.

In your letter of January 3 in regard to this secondary parasite you wrote:

The parasite bred from *Kermes* and the one from confined *Icerya* and which you think to be parasitic upon *Lestophonus* are different species of the same genus. The genus is an entirely new one belonging to the Chalcid subfamily *Elasminæ*. This subfamily is an extremely interesting one, and up to the present time has contained only the typical genus *Elasmus*, so that this finding of a new genus is important. *Elasmus* contains both secondary and primary parasites, so that it will be necessary to secure pretty good evidence regarding this new form before we can accept it as either one or the other.

From seventy-five specimens of *Kermes* no *Lestophonus* was bred. On the 26th I left Adelaide on my way to Sydney, with what I considered even a better shipment than the first. Unfortunately this lot arrived in a bad condition at San Francisco, owing to a gale on the route when the parcels fell off the shelving in the ice-house, in which they had been placed, and most of them were crushed by cakes of ice falling on them. In my opinion, even such severe treatment as this would not destroy so very many of the pupæ of *Lestophonus*, which are not soft, and if crushed out of the scale will produce flies if properly taken care of later, as I had ample opportunity to observe while in Australia.

Among this lot of things were also about fifteen hundred eggs of the *Chrysopa* which were collected on Kangaroo Acacia (*A. armata*) infested by a *Dactylopius*, which is often taken to be Icerya. The scale is sometimes so abundant that the plants are entirely covered with it. This was the case during my visit, and, as Mr. Crawford informed me, also in 1882. Mr. Maskell, to whom specimens were forwarded by Mr. Crawford, said that the insect belongs to the *Dactylopinæ*. The eggs of the *Chrysopa* were so abundant that often from twenty to thirty could be counted on a single small outer branch of a few inches in length, yet many of these had already hatched. The number of Lady-birds in all stages sent with this lot amounted to several hundred. The weather was unusually hot during two days of collecting, the thermometer registered 108° Fah. in the shade, and from one small box left in room over night, where the temperature had not been below 90° Fah., about

fifty of the flies issued during the night and early morning. They were crawling on the window at 6 a. m. Many more were found within the box, with wings not yet developed.

I returned again to Adelaide within four days, the time taken in making the trip. I wrote to the United States consular agent, Mr. George Harris, at Brisbane, Queensland, to ascertain for me the occurrence of Icerya in that district. Through the department of forestry at Adelaide I was informed that Icerya existed at Stansbury, on the Yorka Peninsula, at the place of Mr. F. Wurm. Accordingly a trip was made across the water on October 1, and I was kindly and hospitably received by Mr. Wurm. That gentleman showed me a small orange-tree completely covered with Icerya, but aside from this, not a single specimen could be found for miles around, nor had they ever been observed before this. The tree infested with the scales was completely covered with a small black ant, so much so that several could be counted upon each of the scales at the same time. Upon examination only two specimens of the Icerya were found to be parasitized by the *Lestophonus*, and these had already left. No doubt the abundance of the ants upon the scales prevented the flies from ovipositing. I recommended keeping the ants off the tree as the scales would then disappear.

How often must the mother flies have been hovering over this young tree in their attempt to lay eggs, and how many of them must have been carried off as food for the young of the industrious ants! Mr. Wurm also informed me that Icerya had been found by him upon the roots of black grass. On examination, however, this proved to be an entirely different coccid, *Lecanium oleæ*, which had found its way to this place in small colonies on olive-trees. The cut-worms had done considerable damage to fruit-trees, grape-vines, and other vegetation during November. Some of the apple-trees were completely stripped of their foliage. Melolonthid larvæ had been very injurious to the wheat crop by eating the roots.* The common grasshopper was also in abundance here.†

On December 6, from four large specimens of Icerya that had been inclosed, thirty-four flies (*Lestophonus*) and five parasites of the latter had issued. I examined condition of Icerya on place from which last sending was made, and from which nearly every one of the old and infested scales had been removed, the trees at the time being full of large Iceryas; yet at this date but very few of them were left, the coccinellid larvæ and the Chrysopa in conjunction doing good work, eating, no doubt, the healthy as well as the infested scales. Some of them had apparently gone through second molt, yet the greater part were

* Three species of Melolonthid beetles were collected at this point by Mr. Koebele, and being unknown to our fauna will have to be carefully studied for determination. —C. V. R.

† The same undetermined species referred to on p. 17.

still in the first stage. Only very small larvæ of the *Lestophonus* were found within scales after first and second molts. Within a nearly full-grown specimen on trunk of lemon-tree, the only large one found there, two larvæ of the fly were nearly full-grown.

I left on December 10 for Melbourne, seeing that it was necessary to hunt up a new field. There I had hopes of gathering a sufficient quantity for a shipment. The largest colony I was able to discover at Melbourne existed in a church-yard on Collins street, upon small trees of *Pittosporum undulatum.* I could not find the proper person to apply to for admittance, and a policeman whom I consulted in regard to getting the tempting specimens advised me "not to jump from the fence as they surely would have me arrested."

I left them undisturbed and went in search of others. A few specimens existed in the gardens of the government buildings; an occasional specimen in the park adjoining the Exposition grounds; some on a hedge in front of a hotel, and single specimens were found on trees in a park at St. Kilda, while at the same place on a garden hedge quite a number were found; all these on *Pittosporum undulatum* and *P.* (*engenioides?*). At the last-named place the lady-birds were found at work, and all were gathered later for shipment. I went east of Melbourne as far as Bairnsdale, yet no Icerya could be found. A strong attempt was made to find out the whereabouts of the Monophlœbids of which Mr. Crawford had sent specimens to California. They could not be discovered in numbers in the woods, yet in the parks at St. Kilda I was soon rewarded by finding the insects looked for, viz.: *Monophlœbus crawfordi* Maskell (Fig. 9), under loose bark of various Eucalypti, embedded in cottony matter, and the single, (often 2 inches) long, white, setous, anal hairs sticking out.* Only a few dozen of the monstrous scales, however, could be gathered in a hard day's work. Up in the tree-tops I often found a similar Monophlœbid, only varying in color somewhat. It is as large, or even larger, than *M. crawfordi*, and sits fastened to the branches and exposed without any cottony attachments, although sometimes under chips of bark.

On my way home in the evening one of these scales came hurriedly running down on the trunk of a tree. So the next day, at the northern park at Melbourne, the ground at the base of the Eucalypti was examined. Here I found, sometimes lying loose on top and dead (in this case always destroyed by *Lestophonus*) and below ground to a depth of 3 inches, in a small cave nicely embedded in loose cottony matter if healthy, or generally mixed up with the ground if parasitized, large numbers of these scales. These, Mr. Coquillett informed me on my return to Los Angeles in April, gave the best results in *Lestophonus*, as these parasites were still issuing then, four months after they were col-

*Not mentioned in the description of *Monophlœbus crawfordi.* See "On some New South Australian Coccidæ," by W. M. Maskell. (From the Transactions of the Royal Society of South Australia 1888.)—A. K.

lected. I have counted as many as sixty-two holes in one of these scales, showing what a number of parasites they are able to support. A third species of these large Coccids was found attached to the roots and base of Eucalyptus below ground, even larger than the two preceding. About forty specimens of these produced no parasites. One specimen, probably of this latter species, was found embedded under bark between the forks of a very large Eucalyptus about 8 feet from the ground. This measured fully 1 inch in length, and was about two-thirds as broad, being nearly round.

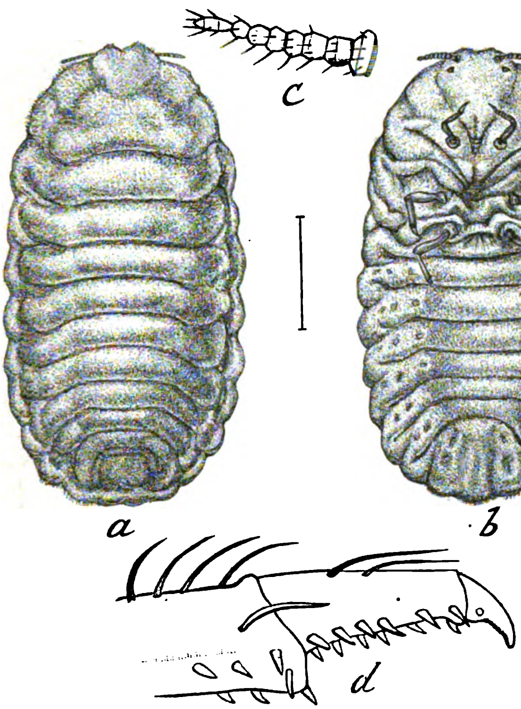


FIG. 9.—*Monophlœbus crawfordi*: *a*, female from above; *b*, same from below—enlarged; *c*, antenna; *d*, tarsus of same—still more enlarged (original).

I left for Sydney on the 24th to place the insects in an ice-house previous to shipment. In the meantime a letter had been received from Brisbane stating that Icerya occurred there occasionally in numbers, and having had a letter from you in which you expressed the hope that I would be able to visit Mr. Carl H. Hartmann, a correspondent of yours at Toowoomba, who had found Icerya on his oranges in 1886, I started for Queensland on December 29 and arrived at Toowoomba early on January 1, 1889. During the same day a full-grown female Icerya was discovered in the woods about three miles from this place on *Acacia decurrens*. During a search of several hours no other specimens were found. I visited the Range nursery the following day and met the son and the brother of Mr. Hartmann, who himself had died from the effects

of fever contracted while on a scientific trip to New Guinea. I also met the man who had been employed at the time in 1886 when Mr. Hartmann received an illustration from Brisbane of Icerya, and directed him to look over the trees for specimens, when several scales were found. Since then, however, none have been found. While looking over the lemon and orange trees I found one single nearly full-grown specimen, but aside from this no trace of them. A peculiar Coccid resembling Icerya somewhat in structure was found on an apple-tree. The gentleman informed me that Icerya was always most noticeable in wet seasons, but that it never appeared in such numbers as to be injurious.

I found here in abundance the large hemipterous insect so destructive to the orange in Queensland and New South Wales. A second species somewhat smaller than this, yet equally mischievous, was found at Adelaide (Fig. 10). Trees were observed at this place with all the fruit and most of the young shoots destroyed. Both species live and grow upon the sap of fruit and tender twigs.* *Aspidiotus aurantii* was present here in numbers and also *Lecanium oleæ*, both upon oranges; the latter, however, is kept well in check by a lepidopterous (*Noctuid*) larva, *Thalpochares cocciphaga*, Meyrick (Fig. 11).

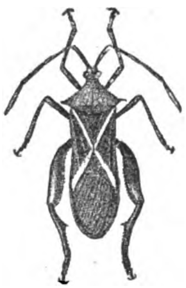


FIG. 10.—*Mictis profana*—natural size (original).

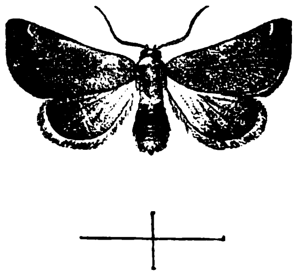


FIG. 11.—*Thalpochares cocciphaga*—slightly enlarged (original).

Several young orange trees had been completely cleaned by larvæ, and eight chrysalids were found upon a young plant. Mr. H. Hartmann also informed me that near Brisbane a dipterous larva existed which occasionally destroyed all the orange crops, and in 1886, which was a very wet season, a dipterous larva destroyed not only all the oranges but also nearly all the other fruits, even the apples and pears. He also gave me the following list as blight-proof apple-trees: "Northern Spy, Majetin, Irish Peach, Streaked Peach, Hartmann's Seedlings Nos. 1 and 5, New England Pigeon, Shepherd's Perfection, Chubb's Seedling, Canvade, Flushed Peach."

On January 5, having obtained free passes for the Queensland railways, I left Toowoomba for Brisbane. On my arrival at the hotel I met with specimens of Icerya on an ornamental plant in the passage-way. This and a few other specimens found in gardens through the city were all I could find, yet in damp seasons they occur sometimes in numbers, as I learned from several gentlemen acquainted with the insect.

Mr. Henry Tryon, assistant curator of the Museum, kindly introduced me to several persons in Brisbane. He himself was about to publish a

* The second of these insects is *Mictis profana* Fabr., and the other is a species of *Aspongopus*.—C. V. R.

paper on Icerya and its parasites, of which he has shown me a small Chalcid of which he bred several specimens from Icerya inclosed in paper box, saying it was a true parasite.* I bred this same insect from a few specimens of an Icerya sent to me by Dr. Bancroft, of Brisbane, as feeding upon mangrove tree (*Avicennia officinalis*, Linn.). This scale differs in coloration from the true *I. purchasi* and may prove to be a new species. Mr. Maskell, to whom the insect was shown, thinks it only a variety. It would be an interesting one, however, for of all the *I. purchasi* that I have seen, none show such a uniform bright yellow color. No specimens found on mangrove at Auckland show such bright yellow color. Mr. Tryon is of the opinion that Icerya originated in China, from the fact that nearly all specimens he found at Brisbane were upon plants from that country. Dr. Bancroft, in his paper on Coccidæ (Philosophical Society of Queensland, vol. 1, August, 1869), referred to the then undescribed Icerya, and at that time, as he assured me, he had been acquainted with the insect for several years. The doctor further mentioned the occurrence of a scale on the sugar-cane in Queensland living on the roots of the young plants, and as these became larger, behind the leaves. It had been imported with the canes from Mauritius. He promised to secure specimens for me. No doubt this will prove to be *I. sacchari*.†

In the woods around Brisbane but few Coccids were found during my brief stay. The white waxy scale (*Ceroplastes*) so abundant on various plants in cultivation was here observed in large numbers upon a small shrub. Of the *Monophlœbus*, which I had been informed was almost always numerous around Brisbane, only an occasional specimen could be found. Everything was so extremely dry that I gave up my intended trip by steamer further north, and as there was little prospect of obtaining sufficient material for a shipment at this place, I returned slowly towards Melbourne, making occasional stops along the road, yet without discovering any Icerya. At Melbourne I was fortunate in finding many more of the *Monophlœbus*. On a few trees, under the bark, they occurred by the dozens, often many together, but they were all dried up and the flies had left sometime previous. Those in ground were still in good condition. A large number of them had deposited their eggs and were shriveled up, yet during the two days a fair number were found parasitized. At Sydney, January 21 to 23, a number of Iceryas with parasites, and probably two hundred or more of the Lady-birds in all

* Mr. Tryon has recently published in a pamphlet entitled "Report on Insect and Fungus Pests, No. 1," a general description of this parasite, but without attempt to name or properly place it. From the description it seems to be identical with a true parasite of Icerya, which we have received from Mr. Crawford, and which we have characterized, since the above was in type, as *Ophelosia crawfordi*, n. g., n. sp.—C. V. R.

† We find among Mr. Koebele's Brisbane material a small Coccinellid not here referred to, but which is labeled "feeding on Icerya." It may be the species referred to in the following paragraph, as found at Sydney, and must remain for the present undetermined.—C. V. R.

stages, were collected, most of them in the Town Hall garden. I found here also feeding upon the Scales a few specimens of a small Scymnus in all its stages which were inclosed. The first brood of Iceryas in warm and exposed places at Sydney had by this time become nearly grown, some of them beginning to exude cottony matter, while others in more secluded spots were quite small. The isolated acacia tree, so full of Icerya in September, had become entirely clear, nothing but a few old and torn egg-masses being visible. With this I finished collecting the parasites and enemies of Icerya in Australia, as from letters received from Mr. Crawford, at Adelaide, dated January 11 and 12, there was little hope of obtaining sufficient material at that place for another consignment, nor would it have paid to search for *Monophlœbus* in the ground, as at the time they could not be found in large numbers in the woods. Moreover, many of their parasites had already left, while the Icerya still known to me at Melbourne and Sydney were not sufficient to make a good shipment.

A letter received at this time from you in which you directed me to visit New Zealand and study Icerya there until the arrival of the next steamer for San Francisco, in case the exposition commission would pay expenses, was shown to Hon. Frank McCoppin, who at once consented to my proposed trip. I therefore left Sydney on the steamer of January 23 with some hope of clearing up the mysterious disappearance of Icerya in New Zealand. Arrived at Auckland on the 28th, the Scales with parasites and Lady-birds were repacked from tin into wooden boxes, and were found in excellent condition. Everything within the tin boxes had the appearance of being placed there only a few hours previous. There was no indication of any mold. Some fresh Iceryas found in a private garden at Auckland, on *Acacia decurrens*, were inclosed as food for the Lady-bird larvæ. These latter Scales were in a small colony all close together on a few small branches, and numbered about eight hundred specimens. No insects preying upon them were found. At the United States consulate a letter was found awaiting me from Mr. R. Allan Wight, dated October 10, 1888, in which the writer mentioned various localities infested with Icerya, wishing me to visit Hawke's Bay, at Napier, where the Scales were still numerous, although fast disappearing, and where a good field for observation would be open. I therefore left Auckland on January 30, overland, the New Zealand Government, through our consul, having furnished me with a free pass for four months. On this trip not many observations could be made.

The Cabbage Aphis was found in large numbers all over the northern island of New Zealand as well as in Australia. A Coccinellid was found subsequently at Napier feeding upon this Aphis in large numbers. It is described by Mr. W. Colenso as *C. nova-zealandica* (Fig. 12). About fifty specimens of these were collected and placed in empty pill-boxes. Of these twenty-one were still living on my arrival at Alameda, where they were liberated. A second species was found feeding upon the Aphis in

small numbers; this is *C. tasmanii* (Fig. 13). The Cabbage Plutella (*Plutella cruciferarum* Zell.) was here as well as all over Australia, observed to be very abundant. Mr. French, of Melbourne, had a specimen on exhibition with the name of "*Plusia crucifera*" as injurious to cabbage. The small Tineid, so destructive to potatoes in California, and no doubt already distributed over the most of the Western States, has been known in New Zealand for years, and it is doing the same mischief all over Australia, where it originated. In conversation with a merchant from Denver, Colo., recently, he said that a year ago he received three carloads of California potatoes, infested with these worms to such a degree that they could not be sold. I also met here, wherever apples are grown, with what is probably *Mytilaspis pomorum* Bouché, the species previously referred to as such.

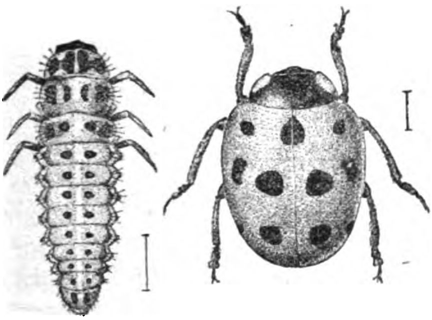


FIG. 12.—*Coccinella nova-zealandica* larva and adult—enlarged (original).

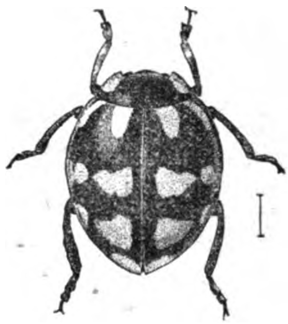


FIG. 13.—*Coccinella tasmanii*, adult—enlarged (original).

Mr. A. Hamilton, curator of the museum at Napier, who had been informed by Mr. Wight of my intended trip, awaited me and at once showed me a number of infested Acacia trees. Icerya was here still in countless numbers. Before breakfast the next morning this gentleman showed me one of the Australian Lady-birds,* saying that he found it among Icerya. On investigation they were found in large numbers in every place visited at Napier and several miles out in the country. I left Napier for Wellington on the 11th to visit Mr. Maskell. This gentleman had never had the opportunity of studying the enemies of Icerya, as the scales are not found anywhere within 80 miles of Wellington. It had been the firm belief of some persons in New Zealand that certain Ichneumonids were the destroyers of the Scales. I saw dozens of several species of these upon one orange tree infested with Icerya near Napier, not injuring them in any way, but devouring the sweet exudation from them. Larger numbers of flies were present than Ichneumonidæ, and even Crambidæ were engaged in the same performance, yet these received no share in the compliments. Mr. Maskell had received from the Cape of Good Hope about two hundred specimens of several species of Coccinellids, which, as the sender informed him,

* *Vedalia cardinalis* Muls.—C. V. R.

were all preying upon Icerya. They were sent to Nelson and placed under tent with the Scales. A few days later, however, the wind took away the tent and nothing more has been seen since of the Coccinellids. Several species of these beetles which Mr. Maskell kindly presented me with were left with you at Washington. Amongst them I could not find the ***Rodolia iceryæ***, Janson (Fig. 14), which is destroying the Scales at the Cape and, with the possible exception of one species, I do not think they will feed upon Icerya.

Fig. 14.—*Rodolia iceryæ*—enlarged (after Riley).

My time was too short to visit Nelson, and Mr. Maskell kindly promised to secure for me a box full of scales from that district, so as to enable me to find out whether some parasites or enemies existed there. This box was sent to me on board the steamer at Auckland and, on opening the same, several flies were found that had issued en route. Only one of them was in perfect condition; all the others were crippled. They had crawled in among the paper used in making up the parcel. No other specimens were bred and no holes were observed in the scales, so the only possibility remains in the larva of this fly being predaceous upon the eggs of Icerya. Apart from these flies no other insects were observed from the Nelson Scales. On my return to Napier I got at once to work gathering the Coccinellids in all stages. They were in such numbers that I found it not very difficult to collect here about six thousand specimens during the three days (February 14 to 16). As many as eight eggs of the Lady-bird were observed on the upper side of the female Icerya just beginning to exude cottony matter. Opposite to this on the small branch of Acacia, five young larvæ of the Lady-bird were feeding on the under side of a half-grown scale; in one instance even nine Coccinellid larvæ were found attached to a small Icerya. The mature beetles were not numerous, but every branch full of scales had a greater or less number of eggs and larvæ. The eggs are chiefly deposited among the vigorous half-grown scales. Here the largest number of the eggs and young larvæ were found. They are generally single, thrust in between the scales and fastened onto the branch, on the scale itself, and often on the under side of the scale, as the mother Lady-bird will sometimes raise the Icerya with her hind legs and thrust the egg under it. At times two or more are found together, always lying flat and in irregular position. Aside from this valuable Coccinellid, a small Scymnus was observed here feeding upon the scales, but in small numbers only. This was named for me later by Captain Broun, as ***Scymnus fagus*** (Fig. 15).

Fig. 15.—*Scymnus fagus*—enlarged (original).

I left Napier with my valuable lot of Lady-birds on the 17th. They

were placed in the ice-house on the steamer, and as soon as Auckland was reached I went to the freezing-house and there my Coccinellids were placed in a cool room with a temperature of 38° Fah. Having been informed that Iceryas had been very numerous almost a year ago at a gentleman's place near Lake Togabuna, several miles out of Auckland, a trip was made as soon as my Lady-birds were safe, for I was very anxious to get at the fact as to what had destroyed the Scales around Auckland, and if it were not the same insect found at Napier. I was shown a couple of Acacia trees, one of which had been destroyed by the Scales, and a second, still living, which had many Iceryas upon it. All the Scales on this small tree were examined, and, with the exception of a small Coleopterous larva within one of the egg-masses, no enemies could be observed. Both these trees were growing among old pine trees and were much shaded by them, in fact so much so that no sun-loving insect like the Lady-bird would venture into them. Close by about a dozen orange trees were growing in an open field, and on my inquiring if no Scales were upon these trees, the gentleman remarked that only about nine months since they were full of them, but that all had disappeared. These I wanted to see, and on the first tree reached, while yet at some distance, I could see, exposed to the sun on the upper side of a leaf, a black glistening spot, which was the insect looked for, the Australian Lady-bird. On this tree more Coccinellids than Iceryas were found. The Lady-birds, if not at rest on top of a leaf in the hot sun, were busily running or flying about. This is an interesting fact. All the orange trees in the open field were completely cleaned of the thousands of Scales by the Coccinellids, while closely adjoining, among the dark and shady pines (*Pinus insignis* Douglas), a large Acacia tree (*Acacia decurrens*) was destroyed by the Scales, even the adjoining branches of the pine trees being dead, and, as stated by the proprietor, from the effects of Icerya.

As yet the scales have not been observed to my knowledge on pine trees in California, yet Mr. Maskell also told me of having seen pine trees loaded with them. I observed here also an *Aspidiotus* very injurious to apple trees. The following day the place visited on my first arrival in Auckland was examined again, but only a few large females could be found. The young were just hatching, and many eggs were still present. Mr. Cheeseman had been informed by Mr. Purchas and others that Icerya existed abundantly in the woods at the English church cemetery (Paeroa), infesting *Sophora tetraptera*. He kindly accompanied me to the place, and before long pointed out the tree, which is closely related to the Acacias. We soon succeeded in finding the scales in large numbers on a few of the trees, when a careful investigation was made and a few specimens of the small *Scymnus fagus* were found. A small hemipterous insect was present among the egg-masses in all stages, the young being found within them, and two species of small spiders had built their houses among the egg-masses

also. From the many remains of the young Iceryas it was evident that they fed also on these. The Australian Coccinellid had not yet discovered this colony of scales, yet it must have existed here in numbers for at least four years. Only a few scattered specimens were found on other shrubs, but they had spread to the Mangrove bushes growing close by in large numbers. On this plant they thrive remarkably well.

Captain Broun, at Drury, the authority on New Zealand Coleoptera, was visited and asked in regard to the Australian Lady-bird. He did not know the insect, nor had he ever met with it, but he had the small *Scymnus fagus*, which seems to be more widely spread and lives upon various Scales; neither had he met with the common *C. nova-zealandica* which I found at Napier. During a ramble in the woods with the captain I found a large Coccinellid in all stages feeding upon *Ctenochiton viridis* Maskell infesting *Coprosma lucida.* This Coccinellid was identified by him as *Leis antipodum* Mulsant (Fig. 16). Upon the same tree was also found in abundance a second and smaller Scale of the same genus; this is *C. perforatus.* The captain kindly promised to send me a number of living specimens of the Coccinellid, and he kept his promise, though, unfortunately, the insect had become so rare that with assistance he was able to find only six specimens. These came in an ice-chamber well packed in a large box, but only one of them was living on arrival here.

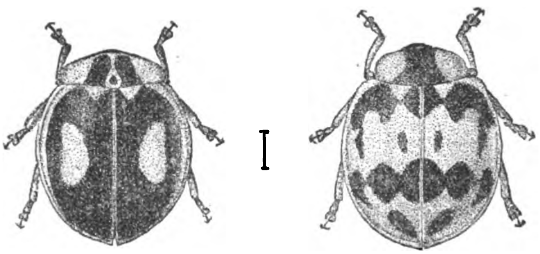


FIG. 16.—*Leis antipodum*, two varieties—enlarged (original.)

On February 25 the steamer was ready to sail. Having made arrangements with the butcher on board the previous day as to the most convenient time of receiving my insects into the ice-house, they were transferred from the freezing-house on board the steamer, which did not take more than ten minutes, and the insects were not disturbed in their dormant stage during the time. Every day on the voyage I received the answer from the butcher, to my inquiries about the parcel, "Your bugs are all right." On March 10, after leaving Honolulu, one of the boxes with the Lady-bird larvæ was examined and found in excellent condition; no dead larvæ could be found among them, and this was twenty-four days after the first were collected. On Saturday evening, March 16, we arrived at San Francisco, too late to have the insects forwarded, and I could not send them off before Monday evening, March 18. They were probably received and opened by Mr. Coquillett two days later. This would make thirty-four days that they were in-

closed, and yet they arrived in excellent condition, better than any previously received. Having been on ice for twenty-nine days, no doubt many of the eggs arrived here before hatching, and the larvæ under such conditions would make little progress in their growth.

As will be seen from these notes (and such is my firm belief), Icerya is indigenous to Australia, having spread from that country to the Cape of Good Hope, New Zealand, and our continent, and no doubt with some plants brought here. The pursers on steamers running between San Francisco and Sydney informed me that with every trip a greater or less number of plants are brought over. On these no one would notice Icerya; even an expert would overlook a few of the tiny young scales if not especially searching for them. At the time Icerya was first observed here many oranges were brought over. Mr. Sutton, of the Alameda, informed me that in 1873 the entire market in San Francisco was supplied with Australian oranges. All this matters little. We have the pest, and now the most effective enemies of it. Before long the work of the latter will be appreciated all over the State. At this date small colonies of the Lady-birds have been established in almost every district infested with Icerya, and at Los Angeles they must be present already by the thousands.

It was difficult in Australia to ascertain which was the most effective enemy of Icerya, on account of the scarcity of the latter insect during the unusually dry season of my visit. It is safe to say, however, that the Lestophonids are always and at any time ready for any Icerya, since they breed upon so many and varied Scales infesting the Eucalypti and Acacias, of which the Australian woods chiefly consist. Often Icerya will appear in large numbers in some private garden in a city, and yet, as I have been informed, they will be out of sight in a short time again. This entire clearing up is the work of the Lady-birds, for in most cases the infested scales will produce eggs, and the flies are never able to entirely clear a tree of them, in which case the Lady-bird steps in and devours Scales, flies, and all. It is only in such protected places that the scales sometimes become numerous, as it takes time for their enemies to establish themselves. The Lestophonus no doubt would in time increase here so as to keep the Icerya in check, but this would be years, for only two broods of it were observed in Australia, as many as that of its host, the Icerya, the parasite appearing about the same time as the young of the latter. I have seen about eight species of Monophlœbidæ upon which Lestophonus will undoubtedly breed.

Dr. Diez, of the Adelaide Museum, has shown me several specimens of a species of these scales, which he assures me were fully 2 inches in length when received alive from the interior of South Australia. He had written to the party who sent them for information regarding the monstrous scale-bug, yet the only light he received upon the subject was that the discoverer of the Scale was found dead in the bush near

Baroota, and he assumes that they came from that district. Such a large Coccid would be able to support several hundred of the Lestophonus. I have also bred this fly from a species of *Cœlostoma* found on a shrub at Mount Lofty, South Australia, where two specimens of Icerya were found, both invested by *Lestophonus* on a species of Acacia. In California we have to my knowledge no Scales upon which this fly would breed, with the exception of *Pulvinaria* and *Dactylopius*. Of the latter there are many species found almost everywhere; a large species almost equal in size to Icerya exists upon our Redwood trees (*Sequoia*). This no doubt will in time be attacked by the flies. I have not the least doubt that in time this *Lestophonus* will do effective work upon Icerya even if slow (too slow for the Americans, as Mr. Wolfskill remarked). So far I have seen little progress of it. On my visit to Los Angeles (April 12), it seemed that very few remained of the vast number of flies received here in good condition. All had been placed under one tent, erected over a tree for the purpose of propagating, instead of forming a new colony with every consignment received; yet it is to be hoped that very many of the flies have escaped from the tent.

As far as the Lady-bird is concerned it will show itself, or rather has done so already. They never were found by the writer except feeding upon Icerya, and yet there must surely exist in Australia some other scales upon which they feed. The work this little insect is able to accomplish is shown by the fact that by chance it went over to Auckland, New Zealand, where the Icerya was in a flourishing state, having destroyed nearly everything about five years or so since, and there cleared nearly the whole district around Auckland within about two years. From here it has spread south as far as Hawk's Bay without any artificial help, everywhere increasing in numbers as long as the food would last. I shall be greatly mistaken if this one insect alone is not master of the situation within two years' time, although we have comparatively few to battle with. It will need thousands everywhere to clean up the millions of scales. I has no time while in the field to study much of the life-history of this valuable insect. My first motto was always "get as many as possible." If once established here, the life history may be studied at leisure.

I will, however, relate part of the doings of one pair of these insects. On February 9 a few beetles and pupæ were collected in a glass jar. Two male Lady-birds were noticed running and pushing around one of the pupæ in which one of the female Lady-birds had just issued and was within the case with soft and tender wings and about helpless. Soon the male succeeded in pushing her out, and immediately after this had been accomplished, one of them united with her at about 3 p. m. This pair were placed in a small wooden box and they remained in copula until the following morning at 7. They were left in this box until February 17, when they were placed in a large jar with twigs of Acacia full of Iceryas. No eggs were observed in the box, which was completely

clean, with the exception of the numerous red spots produced by the Lady-bird, for they had subsisted on their own eggs during their confinement. As soon as the female Lady-bird was among the scales she became quiet, stopped, and deposited an egg upon the twig. As soon as this was done she turned around and devoured the same, which took her about a half a minute. A few moments were spent in cleaning herself and then another egg was brought forth and eaten. After this and another wash she attacked and devoured a half-grown scale. This was eaten into from the back, very quietly at first, yet in a little time she became lively, almost furious, tearing the scale off from its hold by the beak and turning it up and down in the air with the mouth-parts, assisting in this with the anterior legs. In about one minute this was devoured and nothing but the empty skin left, after which she went to work, business-like, and deposited eggs quietly, sitting at rest upon the scales, and every few minutes thrusting an egg in between or generally under them. A very large scale was lifted with the posterior legs and the egg thrust beneath. All the strong attempts at love affairs by the lively and not hungry male were resisted. I was careful to see that twigs with nothing but Icerya on them were selected for food; at least no young larvæ could be observed on them; yet the second day after the Coccinellids were placed in with them, young larvæ were seen, and they came out so fast that within a few days my jar was a living mass of them.

On February 22 a few of the larvæ were full grown and settled down in a quiet place, fastening the ends of their bodies down with a thick and sticky substance and remaining in this way, becoming shorter and stouter, for four days. On the 25th the first pupa was observed; from this the mature beetle hatched in the evening of the 28th. Another appeared the following day. Again, on March 3, a pair of the bred Lady-birds were placed together, with clean food, and the next day, March 4, eggs were observed which hatched on the 8th. This I could not carry through, as the food began to dry up; in fact, on March 18, many grown and hungry larvæ were devouring each other in this jar, and even the mother of them, which was still living, was noticed devouring one of her young, a larva. Three times, at intervals, this pair were observed in copulation. Eleven beetles of this last brood reached maturity, having had nothing to feed upon but one supply of scales that had already been boxed up for eight days, the beetles having been born and forced to live upon one another. Taking four days for the eggs to hatch, about eight days for the larvæ to grow, three days until pupating, and four days more for the pupa to emerge, this would only make nineteen days from the egg to the mature insect, providing the weather is warm. No doubt we will see cases where, in less time than this, all the stages are gone through at Los Angeles in hot weather, and we may expect at least fifteen broods annually of this insect to two of Icerya.

Another most important insect is the moth *Thalpochares coccipkaga* Meyrick. It is greatly to be hoped that this insect will be introduced here. I have been able to get about a hundred larvæ here in good condition, yet what became of them I am not able to state as yet. The insect is apparently easy to breed. Five of the larvæ were placed in a pill-box in the field during January and overlooked. During April, on opening the box at Alameda, I found that four of the moths had issued, copulated, and deposited many eggs. The young larvæ, however, had already left the box and no trace of them could be found. It would have been easy with the number received here, had a little care been bestowed upon them, to breed and introduce them upon most any of our larger Scales.

The *Chrysopa*, of which eggs and larvæ were sent over with every shipment, excepting the last, have been successfully introduced. In April, while in Los Angeles, several of the insects were noticed upon orange trees in Mr. Wolfskill's orchard.

Several species of *Scymnus*, about six in number, that were sent, all live upon *Coccidæ*. The largest of them was abundant in Brisbane upon various soft scales, and was also found at this place upon Icerya.

Mr. Webster brought to me from Tasmania a box full of Eucalyptus twigs with *Eriococcus eucalypti*, the *Scymnus* so numerous at Melbourne, and sent here in numbers, together with two small moths, a Pyralid and a Tineid, which were feeding upon the *Eriococcus*.* These, as all other insects, were turned over to Mr. Coquillett. Various other beneficial insects were observed during my four months' work in Australia, all of which if introduced here would be of great value. One of these deserves to be mentioned. It is one of the largest Lady-birds, and had cleaned whole apple orchards of the Woolly Aphis in South Australia and Victoria. They were also observed to feed upon Lecanium.

All material collected and studied in Australia relating to this subject and otherwise of importance will be mounted and sent to you with the notes thereon.

* These moths we have no means of now determining, even if described. The Tineid much resembles *Euclemensia bassettella* of this country, and the other is a Phycid near *Dakruma*.—C. V. R.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 22.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

(PUBLISHED BY THE AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

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CONTENTS.

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January —, 1890.

SIR: I have the honor to submit for publication Bulletin No. 22 of this Division. Owing to the necessities of the case I was able to include in the annual report only a general summary of the work of the field agents of the Division, reserving their full reports on the work of the year for subsequent publication. They are, therefore, here presented.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

This bulletin comprises the reports of the field agents of the Division of Entomology which were necessarily omitted from the annual report, in which it has been our previous custom to publish some or all of them.

Mr. Coquillett has reported upon several phases of his work, and we print here only the portion relating to the experiments which he made in the destruction of the Red Scale of California (*Aspidiotus* [*Aonidia*] *aurantii* Maskell) by the use of washes. A portion of his report relating to experiments with gas treatment for this scale insect, resulting in the great cheapening of the use of this process, has been printed in the double number of INSECT LIFE for January and February, 1890. Another section of his report relating to the attempted colonization of the insects preying upon *Icerya purchasi*, imported by Mr. Koebele from Australia, has also been published in part in INSECT LIFE for October, 1889, and the remainder is reserved for future use. The experiments with washes were undertaken with a view of presenting a practical illustration of their utility to the fruit-growers of southern California who had apparently ignored the previous results obtained and published in our reports for 1886 and 1887. These late experiments were performed by instruction of Assistant Secretary Willits, and the Red Scale was particularly chosen on account of its importance as a pest, and for the further reason that the Fluted Scale seems at present to require no further experimentation, since the Vedalia is overcoming it so rapidly.

Professor Osborn, in obedience to instructions, has taken up the study of insects injurious to grasses in addition to his regular work upon the insect parasites of domestic animals, and reports at this time upon the leaf-hoppers injuring forage plants. This is a comparatively new and important field of investigation.

Professor Webster continues his studies of grain insects and reports here upon certain points connected with the economy of a few well-known pests.

Miss Murtfeldt sends in a general report upon the insects of the season in eastern Missouri, brings out a number of interesting facts, and gives the life history of a beetle injuring Spinach and also the histories of two interesting Saw-flies.

Mr. Koebele returned from Australia in March and came on to Washington for special work, returning to Alameda, Cal., April 15. He spent considerable time in writing out his report on his Australian work (published in Bulletin No. 21 of this Division) and in assisting to rear and distribute the Vedalia.

During the latter part of the season he did considerable field work and reports upon a number of injurious species. Perhaps the most interesting feature in his report is his work upon the enemies of the Codling Moth in California. He has reared four entirely new parasites of this species, two of which are primary and two secondary. The egg parasite seems to be a very important feature in the life of the Codling Moth on the Pacific coast, and we know from previous experience with egg-parasites of the same genus that they are capable of very rapid development and are consequently very beneficial insects where they attack injurious species. We need only refer to the case mentioned in the Fourth Report of the U. S. Entomological Commission, where by the work of *Trichogramma pretiosa* Riley, the fifth brood of Cotton Worm was almost completely annihilated in Florida, where at the beginning of the fourth brood less than one-half of the eggs had been destroyed. By almost complete annihilation we mean that less than 10 per cent. of the Cotton Worm eggs throughout a large section remained unstung.

Professor Bruner treats of the insects of the year and enters upon the consideration of insects detrimental to the growth of young trees on tree claims in Nebraska and other portions of the West, an important subject which has not before received treatment.

C. V. R.

REPORT ON VARIOUS METHODS FOR DESTROYING THE RED SCALE OF CALIFORNIA.

By D. W. COQUILLETT, *Special Agent.*

LETTER OF TRANSMITTAL.

LOS ANGELES, CAL., *October* 30, 1889.

SIR: I herewith submit my annual report on some of the results obtained by me during the past year.

During the first half of the year nearly my whole time was occupied in propagating and distributing the Lady-birds (*Vedalia cardinalis* Mulsant) recently imported from Australia by this Division. So thoroughly have these insects destroyed the Fluted or Cottony-cushion Scale (*Icerya purchasi* Maskell) that at the present time it is difficult to find a living specimen in any portion of the southern part of this State. From the 129 Lady-birds received from the 30th of November to the 24th of January and colonized under a tent covering an orange tree in this city, by the following midsummer I had, with the help of Mr. J. W. Wolfskill and Mr. Alexander Craw, distributed nearly 15,000 of these insects to various parts of the State, which will give some idea of the great fecundity of these insects. My first attempt at colonizing them on trees in the open air was made in the 35-acre orange grove belonging to Col. J. R. Dobbins, and located in the San Gabriel Valley in this county. I colonized 35 of the Lady-birds on one of the trees February 22 and about 100 more on the 20th of March, and Colonel Dobbins writes me that they had practically freed his grove of the Iceryas by the 31st of July.

The large Chapman orange-grove, also located in the San Gabriel Valley, and comprising 150 acres of citrus trees, has likewise been practically cleared of the Iceryas by these Lady-birds, the first colony of which I placed in this grove on the 20th of March. As might naturally be expected, this freeing of the orange-groves from one of the greatest pests with which they were ever infested removes a great burden from the shoulders of our orange-growers; or, as one of them, Mr. A. Scott Chapman, writes to me: "They have taken more than an oppressive burden off of the orange-growers' hands, and I, for one, very much thank the Division of Entomology for the *Vedalia cardinalis*—the insect that has worked a miracle."

One of the most important results obtained by me the past season has been the discovery of a method whereby trees could be treated with hydrocyanic acid gas at a price scarcely exceeding one-third of what it has heretofore cost by the old method. As the great expense attending the use of this gas has been the one great objection to its being universally employed for the destruction of scale-insects infesting trees, this objection having been now overcome we may naturally expect to see this method coming into more extended use than has been the case heretofore. As I have

given a full account of this new discovery in the report which follows, it will be needless to more than call your attention to it in this place. *

As heretofore, I am indebted to yourself for suggestions and other help.

Respectfully, yours,

D. W. COQUILLETT.

Prof. C. V. RILEY,
U. S. Entomologist.

RESIN SOAPS AND COMPOUNDS FOR THE DESTRUCTION OF THE RED SCALE.

Early in July of the present year I received a letter from Mr. L. O. Howard, acting entomologist during the absence of Professor Riley, instructing me to obtain permission from some person owning a number of large-sized orange trees which were thickly infested with the Red Scale (*Aspidiotus aurantii* Maskell), and then have the trees sprayed with one of the most approved resin sprays obtainable, the spraying to be repeated as often as would be found necessary in order to practically free the trees of these pests, or at least to prevent them from becoming so numerous as to interfere with the healthy growth of the trees, the object sought for being to demonstrate that citrus trees badly infested with these pests can be cleaned and kept in a healthy, growing condition by the use of the resin spray.

Before entering upon this work I concluded to make a series of preliminary tests with various preparations, containing resin and other ingredients in varying proportions, with a view of ascertaining the best and most desirable preparation to use in my field work referred to above. Accordingly I went down to Orange, in the adjoining county, which bears the same name, and, on the 17th, 18th, and 19th of July, made fourteen tests with various preparations, repeating one of these and making several additional tests on the 7th and 8th of the following month. The one giving the best results was used a trifle too strong, as I subsequently ascertained that it produced a discoloration on the underside of some of the oranges, or where they came in contact with each other or with a leaf or branch. For this reason a slightly weaker solution would produce better results, and doubtless the following proportions will be found the most effectual to use during the hotter part of the year:

Resin	pounds..	18
Caustic soda (70 per cent. strength)	do....	5
Fish oil	pints..	2¼
Water to make	gallons..	100

The necessary ingredients are placed in the boiler and a sufficient quantity of cold water added to cover them; they are then boiled until dissolved, being occasionally stirred in the mean time, and after the

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* This portion of Mr. Coquillett's report has been published in advance in INSECT LIFE, Vol. II, double No. 6 and 7 (January and February 1890).—C. V. R.

materials are dissolved the boiling should be continued for about an hour, and a considerable degree of heat should be employed so as to keep the preparation in a brisk state of ebullition, cold water being added in small quantities whenever there are indications of the preparation boiling over; too much cold water, however, should not be added at one time, or the boiling process will be arrested and thereby delayed, but by a little practice the operator will learn how much water to add so as to keep the preparation boiling actively. Stirring the preparation is quite unnecessary during this stage of the work. When boiled sufficiently it will assimilate perfectly with water and should then be diluted with the proper quantity of cold water, adding it slowly at first and stirring occasionally during the process. The undiluted preparation is pale yellowish in color, but by the addition of water it becomes a very dark brown. Before being sprayed on the trees it should be strained through a fine wire sieve, or through a piece of swiss muslin, and this is usually accomplished when pouring the liquid into the spraying tank, by means of a strainer placed over the opening through which the preparation is introduced into the tank.

The preparing of this compound would be greatly accelerated if the resin and caustic soda were first pulverized before being placed in the boiler, but this is quite a difficult task to perform. Both of these substances are put up in large cakes for the wholesale trade, the resin being in wooden barrels, each barrel containing a single cake weighing about 375 pounds, while the caustic soda is put up in iron drums containing a single cake each, weighing about 800 pounds. The soda is the most difficult to dissolve, but this could doubtless be obviated by first dissolving it in cold water and then using the solution as required.

It has been very generally supposed that the finer the spray could be thrown upon the tree the better would be the results obtained, but after conversing with several persons who make the spraying of trees their special work I was somewhat surprised to learn that each of them were in favor of a rather coarse spray. In nearly every instance they had started out with the impression that a fine spray was the best, but had gradually adopted one somewhat coarser, finally adopting one that threw a moderately coarse spray with considerable force. After carefully investigating the subject I found that their reasons for preferring a rather coarse spray to a fine one were well founded.

The object sought for is not so much to simply sprinkle and wet the tree as it is to paint or varnish it over with the compound used, and this can best be accomplished by the use of a rather coarse spray, which enables them to throw the liquid upon the tree with considerable force, so that when it strikes any portion of the tree it spreads out and covers the adjoining parts with a thin film, as if put on with a brush. It also strikes many of the leaves with such force as to cause them to expose to the spray portions of their surfaces that would otherwise escape. Besides this, by the use of a moderately coarse spray the tree can be

wet or varnished over in a much shorter space of time than when a finer spray is used, and all of the operators that I have conversed with on this subject were unanimous in their statements that the time thus saved much more than compensated for the somewhat larger quantity of the preparation that was required when the coarse spray was employed as compared with a finer spray. The evidence, therefore, appears to be decidedly in favor of a rather coarse spray.

But whatever may be the character of the preparation used, or the nature of the spraying nozzle employed, the success of the operation will depend very largely upon the thoroughness with which the preparation has been applied. In the case of small trees it is comparatively easy to wet every part of them, but when the trees are 20 feet or more in height and have not been properly pruned it is not only difficult but quite impossible to wet every portion of them; and, unfortunately, the tendency is to use as little of the preparation upon the tree as is absolutely necessary. On tall trees the operation of spraying is made more effectual by the use of tall ladders, so that the various parts of the trees can be sprayed from above as well as from below.

It is well known among those who have had any experience in trying to destroy the Red Scale with sprays of any kind that the scale insects which are located upon the fruit are less affected by the different liquid preparations than those located upon the leaves or bark. The reason for this appears to lie in the fact that those located upon the fruit, having an abundance of food always within easy reach, are more healthy and vigorous than those located upon the other parts of the tree, and consequently are better prepared for resisting the destructive effects of the spray. That healthy, vigorous insects are capable of resisting the effects of a destructive agency that has proved fatal to their less vigorous comrades there can be no doubt. An instance of this kind is given in my report to Professor Riley for the year 1888, as published in the Annual Report of this Department for that year. On page 128, in speaking of the effects of arseniuretted hydrogen gas upon the Fluted or Cottony-cushion Scale (*Icerya purchasi*, Maskell), the statement is made that "Subsequent experiments made upon perfectly healthy trees and insects showed that when the gas was used strong enough to have proved fatal to all of the Icerya on the neglected trees it did not kill one-half of those on the vigorous trees." Owing to this fact it would be advisable to refrain from irrigating and cultivating infested orange trees for several weeks before spraying them, were it not for the other fact that in the case of bearing trees such a course would seriously interfere with their bearing qualities or operations. Unlike deciduous fruit-trees, our citrus trees do not take a rest of several months' duration between the ripening of the fruit and the blossoming of the trees for another crop; only a few weeks at the most intervening between these two periods in the case of orange trees, while on healthy bearing lemon trees both blossoms and fruit are to be found at every season of the year.

In the case of bearing orange trees it would appear that the season of tho year when they could be sprayed with the least amount of injury to themselves and with the greatest fatality to the red scales infesting them would be at a time when they were in blossom, after all of the fruit of the preceding season had been removed from them. There would at such a time be no fruit on the trees for the scale-insects to locate upon, so that all these insects that could be reached by the spray would be destroyed without at the same time injuring any portion of the tree. Several persons who had sprayed their orange trees at a time when the latter were in full bloom informed me that to all appearances none of the blossoms were injured by the spray, providing that the latter was not used so strong that it injured the leaves, being unanimously of the opinion that the blossoms were as hardy as the leaves. The young fruit is much more susceptible to the effects of the spray than are either the leaves or the blossoms, and this is the case until it becomes at least half-grown. It has been my experience, and also the experience of others with whom I have conversed upon the subject, that where the conditions are equal an orange tree is more susceptible to the effects of a given spray than a lemon tree, the foliage of the latter being hardier; whereas in the case of frosts the reverse of this is true, lemon trees being greatly injured by frosts that would produce little or no effect upon orange trees growing under similar conditions.

It is a well-established fact that any given spray will not be so fatal to the scale insects during the cooler portion of the year as it will if applied during the hotter portion. On this account it will evidently be found necessary during the winter months to use a somewhat stronger solution than indicated in the formula given above; and probably the proper proportions to use during this season would be obtained by adding water sufficient to make only 80 gallons, instead of 100 gallons as given in the above formula.

What is true in regard to the effects of the solution upon the insects is equally true of its effects upon the tree, the same solution that would not injure the tree if applied during cool weather might injure it very severely if applied during very warm weather. As bearing upon this subject, I can not do better than to give the experience of one of my correspondents, Mr. F. G. Ryan, an intelligent orange-grower of Anaheim, in the adjoining county of Orange. Mr. Ryan used the resin compound quite extensively for the destruction of the Black Scale (*Lecanium oleæ* Bernard), and under date of February 7, 1889, he writes me as follows:

I want to tell you of a disappointing experience I had with the resin compound. On January 21 and 22 I sprayed twelve trees in one quarter of the grove and eight in another with a compound composed of 1 pound of caustic soda, 8 pounds of resin and 32 gallons of water. After doing this a hot, drying wind arose and stopped our work. The wind continued for several days, becoming milder each succeeding day, and on the fourth day I noticed some leaves dropping from these trees; this dropping of the foliage has continued and increased until now there is scarcely half the foliage left

on two or three of the trees, and the others show a loss of from 15 to 50 per cent. I argue that as the trees first sprayed show a lesser loss than the others, the probabilities are that the water and compound were not thoroughly mixed, and as it is my custom to keep the inlet pipe of the pump near the top of the solution to avoid the sediment, these trees received a weaker solution, as the compound would remain at the bottom of the tank until thoroughly mixed and suspended in the water. No conditions of health of trees or soil affected the loss of foliage, since similar results are shown by the trees in the other part of the grove. My conclusion is that the cause exists in too strong a solution, followed by hot, dry winds for several days. Since the date of spraying there has been no rain nor even a fog or cloud until two days ago. I am happy to say, though, that the bugs are dead.

That this disastrous result to the foliage was the direct effect of the hot drying wind appears to admit of no doubt, since Mr. Ryan informs me that when no such wind prevailed he had sprayed a large number of his orange trees with a compound made precisely like the one used above, and the trees thus sprayed dropped scarcely a leaf. The fact that the latest trees sprayed suffered the most indicates not so much that they were sprayed with a stronger solution than the others, but rather that being sprayed later and being still wet with the solution they would naturally be more affected by the hot winds than those which were sprayed earlier, and from which the surplus solution had had time to drip off, while the remainder would be quite dry before the hot wind occurred.

Following is an account of a number of experiments which I made with various resin compounds and resin soaps for the destruction of the Red Scale (*Aspidiotus aurantii* Maskell); they were made at Orange, in the adjoining county of Orange, upon trees kindly placed at my disposal by Mr. H. F. Gardner. The trees in experiments 181–194 contained no fruit, but there were green oranges on all of the other trees experimented upon.

In making each of these solutions the necessary ingredients were placed in the boiler, covered with water, and boiled briskly from two to three hours, after which they assimilated well with water; the solution was then diluted with the proper quantity of water, strained through a piece of barley sack, and then sprayed upon the tree. In each instance only a small quantity of solid or semi-solid matter was strained out of the different solutions. An exception to this occurs in experiments 185 and 186, in which the resin was simply dissolved in water over a hot fire, after which the necessary quantity of water was added and the solution strained, as described above. In dissolving the resin I used 3 gallons of water for each pound of the resin; at first I tried to dissolve it at the rate of 1 pound of resin to 2 gallons of water, but a portion of the resin would not dissolve until more water had been added. The solution was of a milky-white color, and assimilated well with water.

The cost per 100 gallons of the different preparations as given below is based upon wholesale prices of the different ingredients, furnished me by the Los Angeles Soap Company, of this city. The rate on resin is by the 10-barrel lot of 375 pounds per barrel; of caustic soda, by the

drum of 800 pounds; of fish-oil, by the barrel of 50 gallons; of potash, by the cask of 700 pounds; and of tallow, by the barrel of 375 pounds.

(181) Resin, 25 pounds; caustic soda, 3 pounds; water to make 100 gallons; costs 65 cents. The diluted solution was of a light brown color. Sprayed on an orange tree at 11.30 a. m., July 17, sun shining, light breeze. August 6, foliage uninjured; found a great many live scales.

(182) Resin, 33 pounds; caustic soda, 4 pounds; water to make 100 gallons; costs 84 cents. Sprayed on an orange tree at 11.45 a. m., July 17, sun shining, light breeze. August 6, foliage uninjured; found great many live scales.

(199, 200) Resin, 25 pounds; caustic soda, 6 pounds; water to make 100 gallons; costs 77 cents. Sprayed on two orange trees at 10.45 and and 11 a. m., August 7, sun shining, light breeze. September 2, found great many live scales, especially on the fruit; leaves uninjured; many of the half-grown oranges have rusty, brownish spots on their under sides, or where they came in contact with each other or with a branch or other object. These spots were still present October 19, but whether they will disappear or not before the fruit ripens remains to be seen.

(201) Resin, 33 pounds; caustic soda, 8 pounds; water to make 100 gallons; costs $1. Sprayed on an orange tree at 11.15 a. m., August 7, sun shining, light breeze. September 2, same as in the preceding experiment.

(190) Resin 16 pounds, fish-oil 6 pints, caustic soda 6 pounds, water to make 100 gallons, costs 85 cents. The diluted solution was of a very dark brown color. Sprayed on a lemon and orange tree (*i. e.* orange budded to lemon, but the orange branches not cut away) at 1:30 p. m., July 18, sun shining, light breeze. August 6, leaves and newest growth uninjured; found ten live scales.

(191) Resin 22 pounds, fish oil 1 gallon, caustic soda 8 pounds, water to make 100 gallons; costs $1.15. Sprayed on an orange tree at 2 p. m., July 18, sun shining, light breeze. August 6, a few of the older leaves have brownish spots on their under sides; found three live scales.

(192,195) Resin 20 pounds, fish oil 3 pints, caustic soda 6 pounds, water to make 100 gallons; costs 80 cents. Sprayed on a lemon and on an orange tree at 1 and at 12:10 p. m., July 19, and August 7; sun shining in the first, cloudy in the second experiment, light breeze. August 6, in first experiment leaves uninjured; found two live scales. September 2, in second experiment leaves uninjured; found 12 live scales on the fruit and 8 on under side of the leaves where they had evidently escaped the spray. In both experiments the fruit was as described in experiment 199 above, but to a less degree.

The formula in these two experiments was the same, except that in 192 one pound more of the resin was used than in 195; but this small quantity in 100 gallons could scarcely have affected the results. This is the same formula used on September 3 of the present year (1889) for spraying twenty-five orange trees, in accordance with instructions

from Mr. Howard, referred to above. Two of the trees were 5 feet tall by 4 in diameter, while the others ranged from 14 to 18 feet tall by from 12 to 16 feet in diameter. They were sprayed between the hours of 3 and 5.30 p. m.; sun shining, light breeze. Three hundred gallons of the diluted compound were used. A tree 16 feet tall by 14 feet in diameter required about 14 gallons of the compound, and three men and a spraying outfit will spray about 800 gallons in a day. The cost of materials and labor in spraying with this compound a tree of the size indicated above amounts to about 24 cents per tree. I examined the above-mentioned trees September 24, and again October 19, and found that the leaves and fruit were uninjured, but a few of the oranges had small brown spots on them as described above in experiment 199. Nearly all of the scales located on the leaves and bark were dead, but about one-fourth of those located upon the fruit were still alive.

(193, 196) Resin 28 pounds, fish oil 4 pints, caustic soda 8 pounds, water to make 100 gallons; costs $1.10. Sprayed on two orange trees at 1.15 and 12.20 p. m., July 19 and August 7; sun shining in the first, cloudy in the second, light breeze. August 6, September 2, and October 19, leaves uninjured; some of the oranges had brown spots on them as described above in experiment 199; found only one live scale on the leaves, and three on the fruit.

(202) Resin 21 pounds, fish oil 3 pints, crude potash 4 pounds, water to make 100 gallons; costs 85 cents. Sprayed on an orange tree at 12.30 p. m., August 8; sun shining, light breeze. September 2, leaves uninjured; some of the oranges had brown spots on them as described above in experiment 199; found many live scales both on the leaves and fruit.

(203) Resin 28 pounds, fish oil 4 pints, potash 5½ pounds, water to make 100 gallons; costs $1.15. Sprayed on an orange tree at 1 p. m., August 8; sun shining, light breeze. September 2, same as in the preceding experiment.

(183) Resin 20 pounds, tallow 6½ pounds, caustic soda 6½ pounds, water to make 100 gallons; costs 98 cents. Sprayed on a lemon tree at 12 m., July 17; sun shining, light breeze. August 6, a few of the older leaves were injured; found great many live red scales.

(184) Resin 25 pounds, tallow 8 pounds, caustic soda 8 pounds, water to make 100 gallons; costs $1.22. Sprayed on an orange tree at 12.30 p. m., July 17; sun shining, light breeze. August 6, leaves uninjured; found three live red scales.

(188) Resin 17 pounds, tallow 6 pounds, caustic soda 6 pounds, water to make 100 gallons; costs 88 cents. Sprayed on an orange tree at 1 p. m., July 18; sun shining, light breeze. August 6, leaves and newest growth uninjured; found twelve live red scales.

(189) Resin 22 pounds, tallow 8 pounds, caustic soda 8 pounds, water to make 100 gallons; costs $1.16. Sprayed on a lemon tree at 1.15

p. m., July 18; sun shining, light breeze. August 6, leaves uninjured; found fourteen live red scales. The pupæ and recently transformed adults of the Chalcid fly, *Dilophogaster californica* Howard, which infested fully 80 per cent. of the black scales (*Lecanium oleæ* Bernard) on this tree, were all of them destroyed by this spray.

(187) Resin 2⅝ pounds, tallow 14 pounds, crude potash 5½ pounds, water to make 100 gallons; costs $1.10. Sprayed on a lemon tree at 4.30 p. m., July 17; sun shining, light breeze. August 6, leaves uninjured; found three live red scales.

(185) Resin 19 pounds, water to make 100 gallons; costs 38 cents. Sprayed on an orange tree at 4 p. m., July 17; sun shining, light breeze. August 6, leaves and newest growth uninjured, but few of the red scales were destroyed.

(186) Resin 22 pounds, water to make 100 gallons; costs 44 cents. Sprayed on a lemon tree at 4.15 p. m., July 17; sun shining, light breeze. August 6, same as in the preceding experiment.

EFFECTS OF THE EUREKA INSECTICIDE ON THE RED SCALE.

On the 1st of August of the present year I received a letter from Acting Entomologist Howard, dated July 25, 1889, requesting me to make a test of the "Eureka Insecticide," put up by E. Bean, of Jacksonville, Fla., who would forward me a few sample cans of the insecticide for this purpose. These samples reached me in due time, and I carefully tested the preparation according to directions. One pound of it was emptied into a vessel, 6 gallons of cold water added, and the whole frequently stirred. After the lapse of one hour I allowed the insoluble portion to settle to the bottom of the vessel, poured off the clear liquid portion, and sprayed it upon an orange tree at 2 p. m., August 7; cloudy, light breeze. September 2 the leaves were uninjured, and I could not discover that any of the red scales (*Aspidiotus aurantii* Maskell) that were encased in a scale or shell at the time the application was made had in the least been affected by the spray.

In a circular received from the proprietor it is stated that this insecticide is sulphur in solution, a patented process, and that it "is absolutely fatal to the rust mite, and also to the scale insect during the breeding or migratory periods," providing that the applications extend through the entire season. It is possible that this insecticide would prove fatal to the recently hatched red scale, but as this becomes covered over with a shell inside of twenty-four hours after leaving the parent, and as the young ones appear during almost every day in the year, it follows that in order to be effective it would be necessary to apply this insecticide every day for three or four months consecutively—a task which very few of our fruit-growers would be willing to perform.

REPORT ON INSECTS OF THE SEASON IN IOWA.

By Prof. HERBERT OSBORN, *Special Agent.*

LETTER OF TRANSMITTAL.

IOWA AGRICULTURAL COLLEGE,
Ames, December 11, 1889.

SIR: I beg to submit herewith my report upon the season's observations and study for 1889.

I have during the season made a series of tests of X. O. Dust under directions from your office; reports of which were transmitted immediately on completion of the tests, and have continued to work, conjointly with yourself, on the insects affecting domestic animals. As bearing upon the same general subject, and connected with one of the most important industries of the State, and, indeed, of a large part of the United States, I have given such time as I could to the study of insects affecting meadows and pastures. Believing, however, that more could be accomplished by giving attention to some particular group, and considering the great importance of the Leaf-hoppers and other Homoptera, and the fact that they have been but slightly studied in this connection, I have spent most of the time upon this group.

The study of these is rendered more difficult in consequence of the great number of species as yet undescribed, and the lack of any complete literature upon known American species. But for these very reasons there is the more need of their being investigated. My results seem meager for the time devoted, but I believe that with the material now brought together much more rapid progress can be made in future studies.

Thanking you for the many favors received from your office, I am

Very respectfully,

HERBERT OSBORN.

PROF. C. V. RILEY,
U. S. Entomologist.

GENERAL OBSERVATIONS.

While no wide-spread devastation has occurred in the State during the past season there has been a considerable amount of damage from a number of different species affecting various crops and operating in different parts of the State.

Cut-worms of different species were unusually abundant, and I received specimens and inquiries regarding them from different parts of the State. They were quite troublesome in gardens, nurseries, and fields in this locality.

The Turf Web-worms (*Crambus exsiccatus*), reported on in detail two years ago, were again quite abundant, but not so numerous or destructive as in 1887. An allied species (*Crambus laqueatellus*) was quite

abundant in the adult form in the latter part of May, and there is good reason to believe that the larvæ have the same destructive habit in grass, and, from the occurrence of the imago so early in the season, it would seem probable that as in *exsiccatus* there are two broods each season.

Another moth nearly related to these web-worms occurred this season in great numbers in pastures and meadows, and though I have not had opportunity to study the larval stage, it may be well to call attention to it as a probable grass pest that may prove as troublesome as the species of *Crambus*. This is the *Nomophila noctuella*, and it was noticed in greatest abundance from May 18 to 22 (1889). The species has been observed as abundant in previous seasons and is probably a pretty constant inhabitant of grass land.

During the latter part of May and first part of June the Blue Grass in the vicinity suffered from the trouble called "Silver Top," the head and upper joint of the stalk turning whitish. I examined a number of these withered and partly wilted stalks and in a few cases found *Thrips* present, and in some cases swollen joints appearing as if affected with *Meromyza*, the adults of which were very plentiful on grass a little earlier. If due to *Thrips*, I think they must leave the grass almost as soon as it begins to wither, as in the cases where I found them I selected stems that were just beginning to turn white.

The Clover-seed Midge has appeared in this State, and the present year is the first I think that it has been destructive. It has been reported in a few localities and I swept the adults from clover in considerable numbers May 25. A very few were bred from clover heads in 1888.

Epitrix cucumeris was very abundant on potatoes, but as the vines had a very vigorous growth in the early part of the season no serious damage resulted.

Diabrotica vittata and *D. 12-punctata* were exceedingly plentiful and furnished me material for some tests of X. O. Dust hitherto reported. I also tried for these a mixture of London purple and kerosene emulsion for the purpose of killing the beetles gathered on the squash vines and preventing the complete destruction of foliage, depending upon the London purple to kill the beetles gathering on the vines later. After this application the vines did very well and I think the plan a success. The beetles will, some of them, fly away before the kerosene takes effect, but they probably all die in a short time. I have since noticed that Prof. John B. Smith has used a similar plan for treating the Elm-leaf Beetle, and it would seem to be applicable in many cases where the expense is not an obstacle and where it is desired to kill the bulk of the insects gathered on plants before they have time to destroy foliage, which they must do to some extent when treated with London purple.

Plant lice of many species were abundant in the latter part of the season. Of these the Thorn-tree Aphid (*Schizoneura cratægi* Oest.) was especially conspicuous by its abundance on thorn trees. The common

Willow Plant-louse (*Melaxanthus salicis*) was brought or sent me a number of times, showing that it attracted unusual attention, and the eggs deposited by the oviparous females were to be found in numbers under the buds of willow twigs in late autumn. Of all the species noticed, however, the swarms of the Dogwood Aphid (*Schizoneura corni* Fab.) were most remarkable. This species is referred to more particularly in another place.

OBSERVATIONS ON INSECTS AFFECTING GRASSES.

The importance of the pastures and meadows in this State will be conceded by every one familiar with its agriculture. Perhaps no other single element is of greater importance, furnishing, as it does, the basis for the stock industry of the State.

The insects infesting meadows and pastures are therefore of the greatest importance, and while their depredations are perhaps less conspicuous than those from insects affecting some other crops, I think it can be clearly shown that the average annual loss in pastures and meadows from insect injuries is equal to if not greater than the crop harvested or the amount consumed by cattle, horses, or sheep in pasture, and probably furnishing a total annual loss greater than in any other crop. In ordinary pasturage it is common, I believe, to allow two acres of land to each cow, or, for convenience, let us say that one acre will half support a cow. At the same time that this cow is feeding there are a million insects, more or less, of various kinds feeding upon the same area by day and night from the time the snow melts in spring till winter forces them to suspend their work.

The only compensation they can offer is that when dead (and they die young), their million little carcasses dropping on the surface of the soil return to it some of the material which has been built into their tissues, increasing its richness and helping to support succeeding generations.

In my report upon the Turf Web-worm two years ago, I gave the count of burrows that had been opened by squirrels as twenty-five in one instance and fifty in another, within a square yard, and it is not probable that every burrow within those areas had been opened by squirrels. The web-worms were, however, uncommonly abundant that season. If we reduce the mean of these figures by one-half and allow two web-worms to each square foot it means 87,120 to the acre, and then consider that these worms cut down quantities of grass that they do not devour, it would seem hardly too much to suppose that these alone would prove a pretty even match for one half a cow in disposing of the grass growing on an acre.

All are familiar with the depredations of white grubs, and it is hardly necessary to ask whether in seasons when these are plentiful they do not destroy as much or more than would support at least half a cow.

Cutworms and Army worms are a constant source of loss in grass

land, and these with the grasshoppers, familiar to everybody, are capable of mowing down a quantity of grass during a season which ought to be appreciated by the farmer. Grasshoppers need not be remarkably plentiful to place a dozen to a square yard, over 50,000 to the acre, and is it any wonder that pastures run short in seasons when rain is scarce or grasshoppers a little more plentiful than usual?

The kinds of insects so far mentioned perform their work in a way that causes an actual lessening of bulk in the crop, but there is another host, less noticeable in size as well as in method of work, whose actual damage in reduction of available food for stock must be of very great importance. These, like the Chinch Bug, which is one of their number, simply puncture the leaves or stems of the grass and pump out its juices, thereby abstracting much of the best food material even where they do not cause a checking of growth and shriveling of the plants. Many of these are insects of very minute proportions, but like the Chinch Bug make up in numbers for their diminutive size. It is no exaggeration I think to say that they occur by the million to the acre.

A million mouths against a half a mouth, and is it necessary that the individual mouth be a very large one to make the aggregate food consumed equal that of the half cow?

In order that my figures may not seem purely fanciful, I may state that they are derived in part from actual count, but in all cases, when count has been made, the circumstances have been such as to make the numbers fall short of the actuality.

I have captured leaf-hoppers on grass by throwing a net down vertically and counting the number caught within the area inclosed by the ring, and while it is hardly possible in this way to secure all that were actually within that area the average of a number of such captures gives nearly a million to the acre.

I have many times observed them when plentiful and tried to count the number within a given area, but their activity makes this difficult. By approaching them very slowly and keeping very quiet, I have on some occasions been able to observe them closely and have on different occasions been able to count many within the area of a few square inches; often two or more to a single blade of grass, and consequently I feel satisfied that the estimate based on the numbers captured are far below the actual numbers frequently occurring during seasons when they are ordinarily abundant and greatly under the number in seasons when they have multiplied to any unusual degree. It may perhaps be urged that, even allowing them to abound in this degree every season, they are too small to consume a very great amount of food. Possibly a million leaf-hoppers would not exceed in bulk the half of an average cow, but it should be remembered also that they grow very rapidly and must consequently use proportionately large quantities of food, and that they extract the most nutritious parts of the grass. That grass forms the bulk of their food has not I think been questioned, but to be certain on

this point I have observed them carefully and examined with particular care the grass blades on which I have seen them established.

On September 7, 1889, I swept grass where no other living plants were to be seen and collected numerous Hemiptera of a number of different species, mostly Homoptera. The grass was very dry, brown, and in many places appearing dead, but evidently still furnishing support for the leaf-hoppers. There were but few other insects present, scarcely any that could be supposed to feed upon grass, except some grasshoppers (*Caloptenus femur-rubrum*, species of *Œdipoda*, etc.). The species of Homoptera collected may I think be considered as unquestionably grass feeders. No other vegetation that could furnish them support had been on the ground swept for weeks, and the insects swarmed on every square foot. The grass commenced turning brown in patches long before it should be expected to, if affected only by want of rain, as it showed within a short time after the last rains, which had been quite regular and copious, previous to the dry period of that time, and its drying up must have been hastened by losses due to the presence of insects. The ground was not yet dry enough so that the grass could have suffered from lack of moisture alone. Their presence on grass seems to show its effect in two ways, though for one of them it is difficult to draw the line between the effects of leaf-hoppers and dryness. In one the effect of punctures shows in numerous pale and dry spots on the blades of grass resembling effects produced by related Homoptera on other plants, apple-trees, pear-trees, grape-vines, etc. Such spots can not be found, however, in such numbers as would be expected if there were one for every puncture by the millions of these insects that occur in every piece of grass land. But the great bulk of the grass is withered or dead down to a certain point near the ground (or to the ground), which would naturally be the appearance if the leaf withered from the lower punctures to the tip, thus obliterating all punctured spots on the terminal portion.

The difference between grass withering from punctures and from lack of moisture is perhaps not sufficiently different to furnish a very safe basis for deduction, but in the latter case it is naturally more gradual and holds for a longer time the green color of hay, so that for withered grass not too long exposed I believe we should be able to distinguish in some degree the difference between that killed by leaf-hoppers and that dried by excessive heat and lack of moisture in the ground.

While this may fall short of actual demonstration, I think a careful study of the effects in the field will convince any one that my conclusions are justified by the facts and that, taking year after year, the amount of injury caused by insects of various kinds is fully equal to the amount consumed by the stock ordinarily pastured on the same land. It is evident, then, that the prevention or the reduction of the insect injuries would add an equivalent amount to the return from such land. Instead of one cow requiring two acres for pasturage, pastures comparatively free

from insects should support a cow to each acre through the entire season. It is certain that much of this loss can be prevented by simple and inexpensive means. The capturing of the moths of Turf Web-worms and Cut-worms will help much in reducing their number. Grasshoppers can be destroyed at the same time that Leaf-hoppers are, and by use of the same means, and it would seem certain that a method costing but 2 to 10 cents per acre might be applied with great profit for these insects alone. It is my object here, however, to treat in detail only of the remedies tried or proposed for Leaf-hoppers.

APPEARANCE AND HABITS OF LEAF-HOPPERS (JASSIDÆ).

The insects embraced in this group are almost all small and rather slender insects, with blunt or pointed heads and well-developed wings, which at rest lie parallel along the back, usually sloping like a roof, or partly inclosing the body. One of the most characteristic features, however, is their habit of leaping when disturbed. All the species possess this habit, though some do not leap as readily as others. The largest species common to grass are not over half an inch in length, while the smaller ones are less than an eighth of an inch long. Many of the species are extremely light and slender, almost invisible except when carefully observed, while others have short, thick bodies. Their colors are well adapted to furnish them protection, many being green, others yellowish or brownish, and in many cases they will not be noticed at all on the grass until they leap, and then it is usually because of the swarm that rise together that they become noticeable. All feed by puncturing the plant and sucking out the juicy contents of the leaves or stems. All, so far as known, puncture leaves or stems of plants to deposit their eggs, frequently placing them under the epidermis only. The larvæ are commonly somewhat spiny at first and have the general form of the adults, passing by gradual development with little change through pupa stage to adult. Most of the species, if not all, pass the winter as adults.

REMEDIES FOR LEAF-HOPPERS.

Burning.—For those species of leaf-hoppers which hibernate in grass, and especially those which are active there during late fall and early spring, a thorough burning over should prove of great advantage. The Leaf-hoppers leap readily, but do not ordinarily fly any distance, and especially when the weather is cool would be unable to escape from the flames. In two pieces of grass land burnt over last spring and convenient for observation one showed fairly good results, keeping its color well till late in summer, though surrounded by grass land, unburnt, on three sides. The other, a pasture of some size, was in poor condition all summer; but in this Turf Web-worms and Cut-worms were so plenty that they alone were sufficient to account for its poor condition.

Plowing.—There seems little ground for hoping that the number of Leaf-hoppers can be diminished materially by any system of plowing under, or by rotation of crops. Grass is an essential on every farm, and no system of starvation could be adopted, and even if deprived of the common pasture grasses, the most of the species evidently thrive on the fox-tails and other grasses that flourish as weeds. The leaf-hoppers are too active to be plowed under and can readily migrate to other fields. Eggs for most of the species, at least, are not deposited at any fixed time of the year, and while by plowing under in May, June, or August many eggs might be buried, plenty of hoppers would escape to the surrounding grass land to keep the farm well stocked.

Mowing.—When the grass in which Leaf-hoppers have been very abundant is cut short, leaving only a dry stubble, the insects seem to be forced to migrate, as few or none can be found in such places a few days after the cutting nor until a new growth gives them a source of fresh food supply. While early cutting of meadows badly infested might result in saving a larger crop, it must follow that the Leaf-hoppers would travel to pastures or other grass land, and it would be simply a question as to where they would do the greater amount of damage. It would seem feasible, however, to take advantage of the time when the crop has been just removed to use hopper dozers or other means for capturing them before they have left for fresh pasture. We know, as yet, too little as to where and when the bulk of the eggs are deposited to say whether cutting at any particular time would result in the destruction of any number of eggs. While we know that Leaf-hoppers deposit eggs in stems and leaves of plants, we are not acquainted with their full history or the methods of different species, so that it would be unsafe at present to base remedies on this part of their history.

Capturing in Nets.—The ease with which all species of leaf-hoppers affecting grass can be taken in sweep-nets led me to try the use of this principle on a larger scale. I therefore had a couple of wire frames made 3 feet long, fastened a deep cheese-cloth net to each and attached these to two long handles, so that the frame of one would brush the ground about a foot behind the forward one. The object of having two nets was to secure the hoppers which allowed the first wire to pass over them before leaping. With the handles the net was pushed forward so that the insects were not disturbed till the approach of the net and a strip of ground a yard wide was gone over either at a walk or a run. While numerous insects were secured by this plan, Grasshoppers, Moths, Clover-seed Midges, and large numbers of Leaf-hoppers, the count of those secured from the nets showed that as compared with what must actually exist on the same ground as shown by other captures, only a portion of the Leaf-hoppers were thus secured, and considering the trouble of holding and destroying all the insects captured, I concluded that this plan was not equal to the hopper-dozer for this purpose. The second net captured a goodly number of insects as well as the forward

one and probably held them better, as they could not as readily fly out after having entered. It was found that more insects were captured when the net was pushed at a run that when walking. Probably even then many insects succeeded in flying out of the forward net.

Nets arranged in this manner, two or even three in succession, might be made eight or ten feet long and run by boys, one at each end. The forward net should be closed as soon as a stop is made, and the nets all closed at the finish, when they may be left a day or two for the insects to die. Usually there are enough predaceous species captured to kill the others rapidly, and such species could then be set free. Many species of insects beside the Leaf-hoppers are caught by this device, and some, such as the moths of Turf Web-worms, and Cut-worms, small Diptera, Clover-seed Midges, etc., that are not as apt to be taken in the hopper dozer.

Hopper Dozer.—This simple contrivance (a sheet-iron pan containing kerosene and water or coal tar, to be dragged over the infested ground), devised for the destruction of the Rocky Mountain Locust, possesses the essential qualities for the destruction of the Leaf hoppers as well. I believe that it can be used with profit in any pasture affected with these pests. The delicate Leaf-hoppers are killed by the kerosene almost the instant they touch it, and though my trials with it were made when the weather was so cool that the hoppers did not leap with their usual activity, they showed that it would operate successfully. It would be best, probably, to use it for these during warm days, when the insects are at their greatest activity, and early enough in the spring to catch the hibernating adults before they deposit eggs, repeating the operation, if necessary, in July, and for meadows immediately after the removal of the hay crop. Perhaps two pans, one behind the other, will prove advantageous.

The Shield Method.—A plan that is scarcely more than a modification of the above has been recently highly recommended for the destruction of the Leaf-hoppers infesting grapes. A quite similar plan was adopted for the destruction of the Rocky Mountain Locust years ago and is described in the first report of the United States Ent. Com.; and in his first annual report as State Entomologist of New York, Professor Lintner suggests its use for "low-feeding insects" "especially hopping species." I have not as yet tested it myself, but will give the plan, that others may test it for these insects if disposed. A piece of drilling or, what would be cheaper still, a strip of building paper is fastened to a light wooden frame and is coated with coal-tar or gas-tar, the residue from distilling off kerosene from petroleum, or from gas manufacture. In case of grape Leaf-hoppers this frame is held as near the vines as possible by one man, while another lifts the branches. The hoppers darting against the shield are caught and killed. For grass Leaf-hoppers the frame would be set on runners and could be made 10 to 15 feet long and run by a boy or man at each end. The best angle at which to

hold it would be soon determined by trials, and if sloping back it might be that the underside of the shield, if coated with the tar, would capture hoppers as well as the upper. As coal-tar can be secured in most towns at small expense, and as the frame for the shield costs but little, this method should be applied at a cost of not more than 5 to 8 cents per acre, and could be repeated two or three times during a season if either Grass-hoppers or Leaf hoppers become plenty.

It could be used in meadows or tall grass by mounting the frames on runners high enough so that the grass while being bent over should have plenty of room to pass under the shield, but would not be likely to work well when pollen is flying from the grass blossoms or when the seed begins to fall, as the tar would so soon become covered with the dust and chaff.

NATURAL ENEMIES OF LEAF-HOPPERS.

But little is known regarding natural enemies for these active little insects. I have found the common *Coriscus ferus* very plenty in all grass land examined, and where but few other insects were present to furnish it food. When left in nets with Leaf-hoppers the latter are soon found dead, while the *Coriscus* thrives, and knowing their very carnivorous habits, there can, I think, be no question as to their serving a useful purpose in killing these as well as other grass pests. As this species does not have the leaping habit it is less likely to be destroyed in "hop-per dozers" than the hopping species, and consequently these remedies can be used with little danger of destroying this natural check to the multiplication of injurious species.

SPECIES OF LEAF-HOPPERS OBSERVED IN GRASS.

THE TENDERFOOT LEAF-HOPPER.

(*Diedrocephala mollipes* Say.)

This widely distributed species is perhaps the most abundant of its genus, and is unquestionably a source of much loss in pastures and meadows. Professor Uhler states its range as "Texas, Colorado, Mexico, and the southern part of the Atlantic region." It is one of the most abundant insects in the Upper Mississippi Valley, and I have found it in great numbers on blue-grass and on prairie grasses, where this must have been its principal, if not only, source of food. Other grasses would seem to serve it equally well. Professor Uhler says (Standard Natural History, vol. II, p. 249):

> The salt marshes of the Atlantic States furnish places of shelter for it, where it may be found on reedy grasses in all stages from June till October.

That it prefers moist places is evidenced by its comparative scarcity on high ground in dry seasons, and its greater abundance in the vicinity of thickets as well as in low ground at such times. It is about one-

third of an inch long, of a bright grass-green color, the head and thorax above yellow. It varies considerably in size, and the females average considerably larger than the males. The head is sharply pointed, has a number of fine black lines on its upper surface; the face is shaded dark brown, and has a double series of transverse bars.

The larvæ which appear to be most common in early summer are light green or yellowish, and agree with the adults in having the head sharply pointed. I have found them most common in May and June, and, as adults are abundant from this time till autumn, it is difficult to say whether there is more than one brood. I have not seen adults in winter or early spring, and it seems possible that eggs in this and allied species are laid in fall to hatch in spring. As this would be contrary to the habit of the majority of insects in this family it will require further observation to establish it. It is at least quite certain that they do not hibernate as adults in grass, and unless eggs are deposited in stems of grass or other plants in grass land the insect can not be destroyed by burning in early winter or spring. It will be seen that there are important points to determine about this very common insect, and means of destroying it may depend in large degree upon the determination of some of the very simple steps in its life-history. It jumps readily, and like other members of the family may be treated on the "hopper-dozer" plan.

THE NEW YORK LEAF-HOPPER.

(*Diedrocephala noveboracensis* Fitch.)

This species is a little larger than the *mollipes*, but resembles it very closely. Its head, however, is less acute, and there are four distinct black spots on the front margin of the head, two of them close together at the tip and one each side in front of the eyes; the lower surface of the head lacks the brown color of *mollipes*, or is but faintly browned. Their habits appear to be much the same, and they are often found in the same locations, though I have found this species more commonly in the grass in wooded pastures or at the borders of thickets. I have never observed it in such abundance as I have the *mollipes*, and ordinarily it is probably of little importance. With equal numbers it would of course be as serious a pest as any of the other species of the family. Professor Uhler says it is common in many parts of the United States north of Maryland and it extends north into Canada and British Columbia.

(*Diedrocephala versuta* Say.)

This species bears a striking resemblance to *coccinea*, and has very similar habits, occurring in similar localities, and probably living upon the same plants. While Say's description was published in 1831 I know of no reference to the species in works on Economic Entomology, and

no reference that would indicate its occurrence in destructive numbers. It is introduced here as one of a group of insects whose importance will I believe be more appreciated when their habits become better known.

THE RED-BACKED LEAF-HOPPER.

(*Diedrocephala coccinea* Forster.)

So far as I have observed this is not an abundant species, and while evidently common throughout the United States I know of no record of its multiplying to numbers sufficient to make it destructive. I have found it usually in the vicinity of timber or thickets, and while it probably subsists on grasses does not select the open meadows or pastures but localities affording more moisture and shade. It is a handsome and conspicuous species, the upper surface when wings are closed being largely of a deep red color with dark blue or blue-green stripes. It was described under the name of *Cicada coccinea* by Forster (J. R.), in 1781 (Novae. Spec. Insect., p. 96), and afterward by Say as *Tettigonia quadrivittata.*

THE HIEROGLYPHIC LEAF-HOPPER.

(*Tettigonia hieroglyphica* Say.)

This was quite an abundant species the past season, but the majority of the specimens taken were found in the grasses of timber or among the low herbage along ravines, grassy banks, etc.

Professor Uhler says it "inhabits Texas, the foot-hills, and plains of Colorado from August to October, and the Atlantic region throughout." It is somewnat smaller than the *mollipes*, usually less than one-fourth of an inch in length; the head is rounded in front and marked with irregular black crescentic spots and bars. There is much variation in depth of coloring and extent of marking so that it is difficult to give a brief description that will be distinctive. While it was described in 1831 by Say, it has not been so abundant or noted as sufficiently destructive to get a place in the literature of economic entomology. Like many other of the species of this family, however, it has been lumped off with many of its relatives among the injurious leaf-hoppers, and hence should not be regarded as hitherto unmentioned among injurious species.

THE FOUR-POINTED AGALLIA.

(*Agallia quadripunctata* Prov.).

This species appears to be common throughout most of the United States, although I am not aware of its having been recorded as occurring in great abundance at any place. It is, however, one of the species which occurs in considerable numbers and does its share toward injuring the vegetation of pastures and meadows.

Whether it feeds mainly on grasses or attacks also the various plants growing with grasses I can not at present say, as it has not been studied in such connection as to determine this point.

It is about an eighth of an inch in length and of a yellowish-brown color with scarcely any decided markings except two black points on the front margin of the head and two similar points at the hind margin of the prothorax. These latter points are nearly in line with those on the head, though a little farther apart, so that the four points stand nearly at the corners of an imaginary square. Other points within the square are in some specimens quite distinct, but not so conspicuous as the ones described. The species appears to have been first described by M. Provancher (Nat. Can., IV, 376), in 1872, but it has quite generally been known among entomologists as *Agallia flaccida* Uhl. Mr. E. P. Van Duzee (Entom. Amer., V., p. 167) says:

This species I have received in exchange from a number of correspondents as *Agallia flaccida* Uhler, and have so used the name myself in exchanging and in the *List of Muskota Hemiptera.* It seems to have been an early manuscript name of Mr. Uhler.

But little can be stated regarding the life history of this species and there are probably no important differences between this and other species of the same family. Nearly all the specimens taken or observed have been mature, and without rearing it would be uncertain whether larvæ apparently of this species really belonged to it. Adults have been taken at different times of the year, and probably it can be found in this condition during each month of the year. Mr. Van Duzee says in the article quoted above that "this is a very abundant species in western New York from early in May until September, and in fact the year round, as it appears to hibernate in the adult state, as do many if not all the *Jassidæ.*"

I have not found it in grass during winter, and can not say whether it hibernates mainly in pastures and meadows or seeks the shelter of dead leaves and rubbish in thickets, hedges, etc.

Agallia sanguinolenta Prov.

This little Leaf-hopper has been quite common in this locality during the last few years, and while never so abundant that it can be counted a serious pest in itself it must be counted in with related species in any enumeration which pretends to give the grass-feeding species. That it has a wide range is indicated by the following from Professor Uhler (Bull. U.S. Geol. and Geog. Surv., vol. II, p. 359 [93, of part], 1876): "This is a very variable little insect, which is not confined to the region of the Rocky Mountains, but which has been found likewise in Texas, in British Columbia, Canada, and New England."

It was described under the name of *Bythoscopus sanguinolentus* by M. Provancher in 1872 (Naturaliste Canadien, IV, 376) and in 1876 by Professor Uhler under the name of *Bythoscopus siccifolius.* Mr. E. P. Van

Duzee has, however, in the Entomologica Americana (V., 166) placed this latter as a synonym, and remarks:

Through the kindness of M. Provancher I had the pleasure of examining a typical example of his species and have thus been able to compare it directly with Mr. Uhler's description, and find that it agrees in every particular. It is not an uncommon species here (Buffalo, N. Y.) on grass and weeds in pastures and road sides, especially where *Carex* and *Juncus* abound.

It is a little smaller than the *quadripunctata* and rather broader in proportion, and is quite readily distinguished from that species by the dark wing veins and the more decided markings on the head and prothorax. It is scarcely an eighth of an inch in length and fully one-third as wide as long.

A dark form which differs from the typical ones, so far as I can see, only in the greater intensity of the markings is perhaps even more common here than the typical form, and this I have found fairly plenty and quite active in blue-grass lawn during the latter part of November, so that we may be pretty certain that it hibernates under grass and probably feeds more or less during mild weather of late fall and early winter. It can also be considered as quite certain that it can live exclusively upon grass, as in the localities where I have observed it it could scarcely have been depending on other vegetation for its food.

THE WAVY-SPOTTED LEAF-HOPPER.

(*Allygus irroratus* Say.)

The propriety of including this species in a discussion of grass insects may possibly be questioned, since its range of food plants is very great. There is no question, however, that plants of the grass family are among those most commonly affected by it, and I have found it abundant in grass land, where evidently this was its only source of food. It will be unnecessary, however, to detail its method of work, as it agrees so nearly with other members of the same family, and all methods of treatment must be based on similar principles. It may be stated, however, that there is as yet no evidence, so far as I know, that it hibernates in grass, and therefore those remedies based on that habit in some of the species will not be applicable to this. Descriptions of the species were published by Say in 1831, and since that time the species has had frequent mention in entomological works, but only occasional reference to it as an injurious species is made, and in these references it is as often spoken of as a grain pest.

THE DESTRUCTIVE LEAF-HOPPER.

(*Cicadula exitiosa* Uhler.)

When attention was first called to this species it was from its attacks on wheat, but that it is of equal if not greater importance as a grass pest seems to me pretty clear after the observations of the present

season, and it would be interesting to know whether, in the reported destruction to wheat, this crop had not followed grass or whether the insects had not simply traveled from grass land. I have taken them in abundance from grass, and in blue-grass, where no other living plants were near, they occurred in large numbers, so that there would seem to be no question as to grass being their natural food. They have been reported as abundant and destructive on timothy in Missouri. (INSECT LIFE, Vol. I, p. 381).

They are about two-tenths of an inch in length, of a brownish color, and the wings are rather prominently marked with dark veins. It is an active species, jumps and flies readily, and is easily captured in a sweep-net, and would probably fall an easy victim to the "hopper dozer" or "shield," where these can be used.

It was described by Professor Uhler in the *American Entomologist*, Vol. III, p. 73 (1880), and a description and an account of its injuries to wheat in the Carolinas and Georgia occurs in the Report of the Department of Agriculture for 1879.

THE HURTFUL LEAF-HOPPER.

(*Jassus inimicus* Say.)

Of all the species of Homoptera that I have observed infesting grass this has been unquestionably the most abundant and constant in its depredations. It is *par excellence* a grass pest, and is found in great numbers in pastures and meadows at all seasons of the year, even in warm days of early winter, being found hopping actively about among the blades of grass and probably extracting some slight amount of food material even during this season. During the past season they have been especially numerous and destructive, or at least my attention has been called to them more frequently than before. My notes show them swarming in May, June, July, August, and September, and, recently, the latter part of November, and, later, December 12. I have found them scarcely less plentiful and active in the grass on blue-grass lawn. I observed them also in great numbers in all the pastures and meadows that I examined while in Linn County, in the eastern part of the State, in the latter part of June. Actual killing of grass by them is, however, a somewhat difficult matter to prove, and, except in seasons of unusual dryness, there is probably not sufficient withering of the grass from their presence to attract attention. In July and August grass here showed injury by turning brown in patches, and this commenced too soon after rains to be referred entirely to drought.

Later in the summer (September 7 and later), when the attacks of the leaf-hopper had caused most of the lawn to appear brown, such patches were not conspicuous. Examination of the grass where blades were not entirely withered would show in many cases brown spots of varying sizes, generally with the center on or near the midrib, and from small

spots of this kind all gradations of withering could be found up to where the entire blade was withered or brown. Plenty of these insects were to be found even where the grass was comparatively dry, but that they preferred the more juicy grass was shown by their accumulation in shaded places or where the grass presented more vigorous aspect. They could be secured in abundance from patches where no other vegetation occurred, and in the absence of other insects in numbers to cause the withering mentioned, there can be no question, I think, as to the serious nature of their attacks upon the grass. Even when they do not cause withering of grass they must draw seriously upon its vitality.

I have thus far been unable to separate any definite broods. Adults occur during the entire year, and larvæ, which may be quite certainly referred to this species, may be found associated with them during the most of the summer months. Larvæ are perhaps most common during June and in August and September, but whether there are two broods or three, or an indefinite number depending only on the length of the season, I can not now say. It seems most probable, however, that breeding goes on irregularly all through the summer months, but that the adults of spring are represented by only two or three generations of progeny, and the members of the latest broods survive the winter to begin the production of new generations in the spring.

In connection with his description of the species, which was published in 1831, Say makes the remark that "When in the larva state this species is said to depredate on the roots of wheat. Several specimens were sent me by Professor Green in the year 1822, who received them from a farmer in Virginia."

Considering the wide distribution and great abundance of this species, it seems strange that it should have been so little studied or so rarely mentioned in works on injurious insects.

The insect is somewhat less than a fourth of an inch long and appears grayish or yellowish gray, and about the most constant marking are two dots on the front of the head, two on prothorax, and two on scutellum. A form lighter than the typical examples but which seems to me only a light variety, has even these dots obscure or wanting.

The larvæ are light yellowish but seem to be subject to about as much variation as the adults. An extreme form of larvæ, probably belonging to this species, has dark margins to the prothorax and abdomen.

Several other species of *Jassidæ* have been observed in grass, but as they are not as yet determined I omit further mention of them at this time.

THE GRASS-ROOT PLANT-LOUSE ALIAS THE DOGWOOD PLANT-LOUSE.

(*Schizoneura corni* Fab.)

Probably the most interesting result of my season's observations from a scientific stand-point, and it may be the most important economically, is the determination of the identity of a form of plant-louse in-

festing the roots of grasses during the summer with one occurring on the leaves of dogwood during autumn. The full import of this connection from the economic stand-point can not be known till it is determined how many species of grasses are affected by the root form and to what extent the migration to dogwood exposes it to attack. If its occurrence is confined to the annual grasses (and it seems to occur only on these), its importance to the farmer will be much less than if it is found to work also on perennial species.

A brief statement of the connection between these two forms was published in INSECT LIFE (Vol. II, pp. 108–9), but a fuller account, with details of observations, is proper at this time.

My attention was first called to this species on September 15, when I noticed the air was filled with small insects, which on capture were found to be plant-lice of the genus *Schizoneura*. Their immense numbers, filling the air as far as could be seen in all directions, naturally excited my interest, and I walked some distance in the direction from which they seemed mainly to come (which was with the wind), but without locating their origin, except to observe that they were resting on all sorts of plants and were very plentiful along roads and paths where fox-tail and other grasses were plenty. Upon examination I determined the specimens gathered to be *Schizoneura corni* Fab., specimens of which I had gathered a year or two ago from dogwood. It seemed difficult, however, to account for such an immense swarm of them when dogwood is not especially abundant in the immediate vicinity and had not been observed as infested with aphids. In looking over descriptions of allied species I was struck by the close agreement with descriptions of *Schizoneura panicola* Thos., and, following this lead, I examined the roots of *Setaria* and *Panicum* on September 16, when the winged forms were again numerous in the air. My search was almost immediately rewarded with the finding of numerous wingless *Schizoneuræ*, and among them some which showed wing-pads and two with wings partly expanded. These were compared carefully with winged *corni* found flying and also with *corni* from dogwood, and showed such close agreement that I felt it important to follow the matter up. One of the specimens, with wings partly developed, was mounted in balsam for future reference; the others, on grass roots, were put in breeding jars. Their subsequent history will be stated later on.

Examinations in the field on the 18th showed lice still somewhat plenty on grass roots, though the *Setaria* examined failed to show them in very great abundance. Examinations the same day, of the dogwood in the timber near, showed on the very first bush noticed numbers of the winged (*pseudogyne*) individuals, and with them numbers of small larvæ evidently just extruded. The colonies accompanying each *pseudogyne* contained from one to a number of larvæ, but none of these could have been more than a day or two old, all very small, scarcely larger than when first born. In no case could I find a leaf on any of

the bushes examined which contained any colonies without the winged mother or where there was the slightest evidence of the previous presence of aphides; no cast skins from old colonies or damaged leaves, and every indication went to prove that the winged form had just settled upon the trees and begun the formation of colonies. While perhaps of little value as proof, it may also be mentioned that no Schizoneuræ had been observed on *Cornus* this fall prior to this date or before the swarming of September 15. A number of branches containing colonies were brought in and kept in water for the purpose of following their development. This was fortunate, as the colonies on the plants out of doors were almost all depopulated a few days later by predaceous insects, so much so that the colonies on plants near at hand and on which I depended for following the species out of doors utterly failed to furnish material for that purpose. Indoors the insects developed rapidly and were followed as closely as circumstances would permit. Molting in these occurred by the 19th, and apparently only one molt occurred before maturity. Only one brood was developed, these becoming sexually mature September 25. Both males and females were apterous and copulation took place upon the leaves and also upon the twigs, the females often traveling down the twigs and branches while copulation was in progress. In every case the females seemed to travel down the branches as far as possible before depositing eggs, and great numbers of them dropped into the water in which the branches were kept. In the woods I have been unable to find any eggs whatever under buds on twigs, and so far as the indoor observations go they differ from those recorded by Mr. Weed. Whether this be due to dryness, the insects seeking a place of some degree of moisture, can be determined by comparisons under varying conditions.

Two weeks after the swarming of winged lice in the air there was another swarming, though the lice were not so numerous as at the first time. This swarming also followed a rain with subsequent cold. As in the preceding case, examination of *Cornus* in the woods showed numerous winged individuals starting colonies, though at this time in some places it was possible to find the cast skins of previous colonies, all of which, however, so far as I could find, had been destroyed by predaceous insects or other causes. My search for eggs in the woods has been futile, and it would seem that nearly all the colonies were destroyed before the maturity of the sexual individuals. I have found, however, oval bodies a trifle larger than the eggs, but resembling them at first sight, though flattened, but which prove to be a small species of *Lecanium*, apparently undescribed.

The lice occurring on the roots of grass, and which were placed in breeding jar the 16th, were mostly unaltered on the 19th, but in the jar I found a fully winged specimen, agreeing exactly, so far as could be seen with hand lens, in the living individual, with specimens flying and also with those on *Cornus*. It was transferred to a leaf of *Cornus* on

twig inserted in water, isolated from other leaves, and which had been carefully examined with lens to see that it was free from larvæ, and protected by cheese-cloth cover. This individual took kindly to the situation, remained constantly on the leaf, and produced a number of larvæ which developed as rapidly as those brought from the woods, agreeing perfectly with them in every particular that I could observe, and proving their ability to develop on *Cornus*. Unfortunately their propensity for traveling down the twigs resulted in their being drowned in the water in which the twig was kept. I think, however, that their developing perfectly on the Cornus leaf, and the perfect agreement of apterous males and females so developed with those occurring normally on *Cornus* in woods, is good evidence of identity.

In the meantime lice had been found in some numbers on the roots of grasses not yet dead, especially on *Panicum*, and many of these had been placed in breeding-jars in hopes of securing additional winged specimens. While apparently thriving they failed to acquire wings, but on September 24 I observed in one of the jars an apterous individual, and directly behind it an egg evidently fresh-laid, elongate, oval, greenish, polished, like eggs of *corni* on *Cornus*. This was mounted with the apterous individual, and in the body of the latter another egg was apparent. The egg was laid at the surface of the earth in the jar, and similar eggs were found in pill-boxes in which root-lice were confined. A close examination of roots, especially those of *Panicum* from the field, enabled me to find a number of small apterous individuals like the males on Cornus leaves, as well as the small apterous and oviparous females. These occurred with a larger form, exactly like those which had been observed to acquire wings, and the conclusion seemed inevitable that these viviparous and apterous forms produced in the ground a brood of apterous males and females. These latter were observed attempting coition, though in no case did I see the act completed. The males are of an orange color, darker than the females, and differ from males on Cornus leaves in being shorter, and in lacking the purplish tint usually present in those. The females agree well with females on Cornus leaves, but are shorter, have *six-jointed* antennæ, and are slightly lighter colored, which would be expected in individuals living under-ground. September 28, eggs from these root-forms were more numerous, and by October 3 I found them quite plenty in my jars. One oviparous female was observed with three eggs extruded from the body, adhering by the ends, and the last one still partly within the body. They are whitish at first, but turn yellow on exposure, and later turn quite dark.

The eggs seem to be deposited at hap-hazard on surface of earth, sides of boxes or jars, and each female appears to produce but two or three eggs.

These observations, I am free to confess, appear to complicate the round of life of the species, and to make the complete circle from grass

to dogwood and back less clearly defined, but such a dimorphism, if we may call it so, is not without parallel, and does not seem unreasonable. There seems reason to believe that while a large proportion of the *pseudogynes* acquire wings of perfect development, and migrate to dogwood, that there is also another portion in which the wings for some reason fail to develop, and these from necessity remain on the roots or at best remain near the surface of the ground, and the sexual generation produced by them at the same time as from the winged ones, or perhaps a little later develop by feeding upon grass roots, and deposit their eggs where they have themselves developed. As to whether these eggs are as successful in their further development as the ones deposited on *Cornus* remains for further observations to determine. Possibly in certain seasons they may survive better, and thus provide a double means for the preservation of the species. As to the conditions which might affect the acquisition of wings we can do little more than speculate, but it seems proper to call attention to the possible elements that may furnish a solution.

The day before the first swarming of *Schizoneura* (14th) had been very warm in the middle of the day, with a heavy shower in the latter part of the afternoon, followed by a steady rain in the fore part of the night, and this by a sharp fall in temperature, so that the morning of the 15th was clear and cold (possibly a slight frost). The day remained cold, but was bright and sunny, and the swarming observed occurred in the latter part of the afternoon. Some other aphids were observed on the wing, but very few as compared with the swarms of *corni*. *S. corni* was seen in the air on subsequent days, but comparatively scarce till, again two weeks later (29th), after a very similar condition of weather (warm, with rain, followed by cold), when another swarming occurred. Now, it may be that those individuals, which are at a certain stage when such conditions occur, are enabled to acquire wings while those less fully developed remain without the full expansion of these appendages.

In comparing the two forms infesting grass roots and dogwood, respectively, I have studied great numbers of wingless individuals, winged forms and apterous males and females, and have come to the conclusion that they must all belong to the same species. It will, however, be in place, I think, to place in position for comparison the different descriptions which have been given of the species to show that, notwithstanding the terms used by different authors, and their wide separation in time and place, there is no real discrepancy in them. The original description by Fabricius is very short and general, and is as follows (Ent. Syst., IV, p. 214, No. 19):

Corni. A. Corni sanguineæ.

Habitat in Corni sanguineæ foliis.

Corpus nigrum abdomine basi et subtus virescente. Pedes nigri. Anus absque stylo et corniculis.

Juniores pallidi macula magna, dorsali, nigra.

Passerini, in Gli Afidi (1860), describes the root form as follows:

Schizoneura venusta, m.

Femina vivipara aptera ovata-convexa, pallide viridis, vel interdum rubella; capite, fasciis dorsalibus anticis tribus, macula discoidali quadrata, fasciis posticis duabus, punctisque marginalibus nigris. Rostrum crura media attingens. Long., 1‴.

Femina vivipara alata capite et thorace nigris. Abdomen viridi luteolum vel rubellum, vittis transversis anticis duabus, macula discoidali subrotunda, fasciis duabus posticis, punctisque marginalibus nigris. Nectaria tuberculiformia nigra. Alæ hyalinæ, venis stigmateque nigris. Long., ¾‴, 1‴.

Nympha lutea, capite et thorace pulverulentis.

Turmatim in radicibus Setariæ viridis, S. glaucæ, S. italicæ, Panici glabri, Eragrostidis megastachyæ et Ceratochloæ australis. Autumno.

Valde similis *Schizoneuræ corni*, quæ autem diversa dorso omnino nigro in apteris, et abdominæ basi et apice tantum albido in alatis.

Thomas gives a translation in his work on Aphidæ, which reads:

Schizoneura venusta Pass.

Wingless female.—Ovate convex, pale green, and sometimes reddish; head, three anterior dorsal fasciæ, a quadrate discoidal spot, two posterior fasciæ and marginal points, black. Rostrum extending about to the middle legs. Length (of body), 1mm.

Winged female.—Head and thorax black. Abdomen, greenish-red or yellowish; two anterior fasciæ, a subrotund discoidal spot and marginal points, black. Nectaries tuberculiform and black. Length, ¾ to 1mm.

Pupa, yellowish, head and thorax pulverulent. Found on roots of *Setaria viridis*, *S. glauca*, *S. italica*, *Panicum glabrum*, *Eragrostis megastachya* and *Ceratochloa australis* in autumn.

This translation is incomplete and imperfect, especially in the dimensions, which are given as millimeters instead of lines (twelfths of an inch), which would lead one to suppose them about half the actual size. So far as I can see, Passerini's original description is entirely applicable to the specimens obtained from roots of grasses here as well as to fresh specimens of *corni* on *Cornus* leaves.

Walsh published the following descriptions (in 1862) in the Proceedings of the Entomological Society of Philadelphia, Vol. I, p. 304.

Eriosoma ? fungicola n. sp.

From recent specimens. Body black, with a plumb-like bloom; basal half of abdomen and whole of venter yellow. Antennae and legs black. Wings hyaline with a dusky tinge; veins dusky, black on the basal half of the costa; third discoidal hyaline nearly to its fork, stigma palish brown. Numerous individuals unaccompanied by larvæ, occurred on a large moist fungus a hundred yards from the nearest trees, which were all oaks. Beat solitary individuals unaccompanied by larvæ or woolly matter, on two separate occasions from oaks, which, when dried, differ only from the dried specimen of those found on fungus by the metathorax being varied with pale greenish, as well as the base of the abdomen. Length to tip of wings .12 to .13 inch.

The antennæ do not quite attain the base of the first discoidal when the wings are expanded, and the stigma is rather more than twice as long as wide. Six specimens in all. *E. querci* Fitch is larger (.16 inch) and is entirely black. Differs also from the other described United States species.

Eriosoma ? cornicola, n. sp.

Differs from the preceding only in the body being entirely black. Numerous individuals, unaccompanied by any flocculent matter, and so far as I recollect by larvæ, occurred in September on the lower side of the leaves of the Red osier dogwood. Ten specimens.

Dr. Thomas, in repeating these descriptions in the "Aphididæ" (8th Report State Entomologist of Illinois, pp. 141, 142), separates the two by *Schizoneura caryæ* Fitch; so that "Differs from preceding only," etc., refers to *caryæ* and not to *fungicola.* This circumstance is liable to mislead, unless Walsh's original descriptions are at hand for reference, and may account for the uncertainties that have been stated in efforts to determine Walsh's *cornicola* found on *Cornus.*

Considering that *fungicola* was on a fungus, a plant never known to support Aphides, and that the difference noted by Walsh is such as results from greater maturity of specimens that have located on *Cornus*, and further, that *fungicola* agrees perfectly with both descriptions of *corni* and with fresh individuals found on *Cornus* leaves, it seems pretty certain that these two descriptions refer to one and the same species.

Thomas' description of *S. panicola*, published in 1879 (8th Report, State Entom., Illinois, p. 138), is as follows, and is said to have been written from recent alcoholic specimens:

Winged female.—The front wings with the third discoidal veins once forked; third vein obsolete at base; first and second veins arising very near each other; stigma short, rounded behind; fourth vein nearly straight; costal bent outward to the base, leaving a rather wide space between it and the subcostal; antennæ short, reaching about to the base of the fore wing; slightly hairy; third joint rather longer than the fourth and fifth united; sixth slightly longer than the fifth, with a very short, indistinct, blunt spur at the tip; beak rather long, reaching nearly to the hind coxæ, slightly hairy; eyes present and of the usual size or nearly so.

Wingless female.—(Probably not fully developed.) Very broadly ovate and very convex, being suborbicular; antennæ, reaching about to the end of the thorax, rather thick and heavy and not tapering to apical joints, if any difference rather thicker than the middle ones; third joint longest but not quite equal to the fourth and fifth united; fifth rather longer than the fourth, gibbous on one side at the tip; sixth nearly as long as the third; beak, long, reaching fully to the hind coxæ; color of the alcoholic specimens, reddish-yellow; eyes minute and black.

Found on the roots of *Panicum glabrum* and other grasses by H. [Th.?] Pergande at St. Louis, Mo., in November.

The difference in the length of the beak will certainly distinguish this from *Tychea panici*, even supposing the antennæ in the latter to be undeveloped.

Mr. O. W. Oestlund, in Synopsis of the Aphididæ of Minnesota (Bull. No. 4, Geol. and Nat. Hist. Surv. of Minn.) describes both *corni* and *panicola*, and their identity could not be more strikingly indicated.

S. corni.

Head and thorax black; abdomen reddish-black, with a large patch of velvety black covering all of the dorsum except three and some of the last segments. Antennæ reaching to the end of thorax; not annulated, hairy, with a single row of circular sensoria on the under side, about six to the third joint, three to the fourth, two to the fifth, and one at the contraction of the sixth; III, 0.30^{mm}; IV, 0.12^{mm}; V, 0.10^{mm}; VI, 0.15^{mm}, with the short unguis. Beak reaching third coxa. Wings hyaline, with slender veins; cubital obsolete at base; stigma broad and short, smoky. Honey tubes a circular opening almost on a level with the abdomen. Expanse of wings, 6–7^{mm}.

S. panicola.

Head and thorax dusky or black; abdomen pale greenish with some black marking above, on the last segment at least. Antennæ reaching to the end of the thorax,

hairy, third joint the longest, the following subequal; sensoria rather indistinct, three or four to the third joint, and usually one or two to each of the following. Beak reaching abdomen. Honey tubes as circular openings on level of surface of abdomen, but rather conspicuous from being bordered with a ring of black. Wings hyaline with slender but distinct veins. Fore wings with the cubital obsolete for some distance at base; stigma short and broad; stigmal vein but slightly curved near the base, straight. Expanse of wings, about 5^{mm}.

Careful descriptions of the different forms on *Cornus* are given by Mr. Clarence M. Weed (Psyche, V, p. 129), the species being referred doubtfully to *cornicola* Walsh.

Winged viviparous female (*pseudogyna pupifera*).—Expanse of wings, 6^{mm}; length of body, 2^{mm}; width of body, $.80^{mm}$; length of antennæ, $.90^{mm}$.

Black above, except anterior and lateral margins of abdomen, and in many specimens more or less of posterior portion. Beneath black, except prothorax and abdomen (save a black patch in front of anus), which are dull whitish-brown. Rostrum black, except a more or less distinct lighter patch near base, hairy, reaching posterior coxæ. Legs robust, black, except a short brownish space at base of anterior femora; thickly provided with brown hairs. Antennæ robust, beset with brown hairs. Joints I and II, short, smooth; III, long, with row of tubercles on its outer ventro-lateral surface; IV and V subequal, with tubercles as on III; VI, a little longer than V, excavated on its outer lateral surface about two-thirds distance from base. Wing veins mostly brown. Stigma brownish, with interior portion darker.

Described from many specimens taken October 24, 1887, on leaves of *Cornus sanguinea* and *C. sericea*, where for some time previous they had been very numerous, founding sexed colonies. Usually occurring on the under surface.

Apterous male.—Width of body, 0.50^{mm}; length of body, 0.89^{mm}; length of antennæ, 0.47^{mm}.

Body and members brownish or brownish-black, with numerous brown hairs. Eyes black. Body flattened, long and narrow, with nearly parallel sides. Antennæ half as long as body. Joint I, short, swollen; II, small; III, longest; IV and V, subequal; the latter excavated on its apical lateral surface. Legs long, robust, same color as body. Rostrum robust, reaching anterior margin of posterior coxæ.

Described from several living specimens (part taken *in copula*) from *Cornus sericea*, collected October 24, 1887.

Oviparous female.—Width of body, 0.50^{mm}; length of body, 1.14^{mm}; length of antennæ, 0.35^{mm}.

Green, or greenish-brown, slightly darker anteriorly. Shape, elongate oval; sparsely clothed with brown hairs. Eyes blackish. Antennæ green, slightly darker apically; joint III longest, V slightly swollen in middle. Rostrum robust, green, darker at tip, reaching anterior margin of posterior coxæ. Legs unicolorous with body, dusky apically.

Egg.—Elongate oval, 0.56^{mm} long, 0.20^{mm} wide.

Green at first, becoming black by exposure. Deposited on bark, in and about the axils of buds and small branches.

Described from many specimens on *Cornus sericea*, October 24, 1887.

These descriptions are so full that I deem it unnecessary to draw up another. I may mention, however, that the apterous males usually have what I should call a purplish tint with the brownish color when alive, due, perhaps, entirely to the delicate bloom covering them.

The most distinctive character of *corni* is perhaps the hairy antennæ and the six or seven circular sensoria on underside of the third antennal joint. The number of these sensoria varies slightly, but in the form I

reared from grass roots and allowed to colonize on Cornus leaf there are the full number common to *corni* and show distinctly. Mr. Oestlund's statement that they are indistinct and but three or four in number might, I think, apply to an extreme variation or to specimens fresh from the ground. The dark spot on the dorsum of the abdomen is not only variable in size but differs much in appearance with the age of the specimen and in dead or preserved specimens. While I am free to admit some puzzling questions, I am strongly convinced of the main point here claimed. There is certainly much more of interest to be learned regarding the species. I feel that only a beginning has been made, and shall watch eagerly for further developments. As the Aphides are so uncertain in their appearances and can not be depended upon to furnish material in abundance in every locality, it will add to the certainty of completing the history of this species if entomologists in various localities will make such observations as possible the coming season.

If my conclusions are correct the synonomy for this species will read as follows:

(1794) *Aphis corni* Fabricius, Ent. Syst., IV, 214.
(1860) *Schizoneura venusta* Passerini, Gli Afidi, p. 38.
(1862) *Eriosoma? fungicola* Walsh, Proc. Ent. Soc. Phila., I, 304.
(1862) *Eriosoma? cornicola* Walsh, Proc. Ent. Soc. Phila., I, 304.
(1879) *Schizoneura panicola* Thos., 8th Rep. Ill. Ent., p. 138.

SUMMARY.

Schizoneuræ abundant on grass roots and assuming winged form in latter part of September (15–28) and on several days during this time the air was filled with like insects, and immediately following these flights apparently identical Aphides were colonizing on leaves of dogwood, which had hitherto been free from them.

Schizoneura (winged *pseudogyne*) reared from grass roots and transferred to leaves of *Cornus* established colonies apparently identical with those occurring normally on *Cornus*.

Schizoneura (apterous individuals) in some number remain on grass roots and are associated with apterous males and females, the females of which are oviparous.

Individuals of these different forms agree with each other and with descriptions of both *corni* and *panicola* and differences do not exceed the range of variation common to species of Aphididæ.

CONCLUSION.

Taking all these facts into consideration, I believe that the species of *Schizoneura* infesting grass roots and dogwood leaves and described as distinct species are identical.

That the winged generation of asexual individuals produced from grass roots in autumn migrate to leaves of dogwood of different species and establish colonies of apterous individuals, which become sexually mature and the females of which deposit eggs on dogwood.

That the number of broods produced on *Cornus* in spring (which must now be inferred) and the time of return migration to grass are yet to be determined.

That in addition to the migratory winged autumn brood there appears to exist under certain conditions an apterous form which produces a brood of sexual individuals on grass roots the females of which deposit eggs the fate of which is unknown.

HETEROPTERA INFESTING GRASS.

The Chinch Bug.

(*Blissus leucopterus* Say.)

The Chinch Bug is too well known as a grass and grain pest to need any special mention in this connection. It may be noted, however, that it prefers the annual grasses rather than perennials, and were it confined to the noxious Foxtails (Setaria) we might have no reason to complain, but its fondness for Hungarian grass is too conspicuous to pass over. It does not appear to multiply as rapidly in sod land, though I have found it in Blue-grass where this alone could furnish it food.

The Long Bug.

(*Ischnodemus falicus* Say.)

Were it not for its elongated form this species could be most easily mistaken for the Chinch Bug, for, excepting this peculiarity, it comes nearer in appearance to the Chinch Bug than any of the numerous species which have been confused with that noted pest.

Hitherto I believe it has not been classed among insects of economic importance. It is, however, quite evidently increasing in numbers in this region and should, I think, be mentioned, at least, in this connection. That it is a grass-feeding insect is evidenced by its abundance in all stages in grass land where other plants are scarce or wanting, and would be expected of an insect so closely related to the Chinch Bug. I have found it more common in rather low ground, and especially in the wild grasses between upland and bottom-land, or along the borders of sloughs or small streams.

While only a fall brood of larvæ, developing in July and August and maturing in September, have as yet been observed, it is probable that, as with the Chinch-Bug, there are two broods each year, adults of the second hibernating and depositing eggs in the spring.

If multiplying, so as to become a serious pest, I know of no remedies to suggest further than those applicable to Chinch Bugs, and probably the most efficient one would be that of burning dead grass and rubbish in the fall.

There are several other species of the Heteropterous Hemiptera, notably certain *Capsidæ* such as *Miris affinis* and related species, and several species of *Lygus*, which I suspect will be added to our list of grass pests, but I have as yet made no careful study of their habits.

REPORT OF OBSERVATIONS UPON INSECTS AFFECTING GRAINS.

By F. M. WEBSTER, *Special Agent.*

LETTER OF SUBMITTAL.

LA FAYETTE, IND., *December* 14, 1889.

SIR: I herewith transmit my annual report of observations on insects affecting cereal grains, made under your direction, during the current year. A more elaborate report, treating of the destructive grain insects of the United States, to be prepared jointly with yourself, is nearing completion, and the present report is submitted now, in order to avoid the necessity of including details in the more important work to follow. As usual, I am under many obligations for the determination of specimens and numberless other courtesies.

Respectfully submitted.

F. M. WEBSTER.

Prof. C. V. RILEY,
U. S. Entomologist.

THE WHEAT STRAW WORM.

(*Isosoma tritici* Riley.)

These insects have not been observed by me in any great numbers since they were last treated in my reports, and the species is only mentioned in order to record the occurrence of a female of the wingless spring form, on the 18th of July, in a field of wheat.

THE WHEAT STEM MAGGOT.

(*Meromyza americana* Fitch.)

Since the establishment of the fact of a summer brood originating during the month of August, and largely, it is supposed, in volunteer wheat, considerable emphasis has been placed upon the destruction of this illegitimate growth of grain. There has, however, been pretty good cause for believing that the insect developed also in other plants, and this season we have reared the adult from Blue grass, *Poa pratensis*, during the latter part of August.

Since the discovery of the species there has been nothing placed on record relative to its discrimination between varieties of wheat, or

whether these insects really possessed any such instincts, the inference having been that one variety was as acceptable to them as another. Bearing upon this point I have obtained some interesting information, which, though by far too slender a thread on which to hang a positive assertion, yet forms sufficient grounds for a suspicion that the species may possess some exceedingly fine instincts regarding plant tissue.

In the month of September, 1888, a field of oat stubble on the experiment farm was subdivided, two plats each several acres in extent being sown, the one to velvet chaff and the other to Michigan Amber wheat. Between the two was a narrow strip comprising a mixture of both varieties. From the beginning of preparation of the ground to the end of harvest this year all conditions excepting seed were exactly the same.

The attacks of these larvæ were quite severe during June, and on the 14th of this month an examination of the plats above mentioned developed the fact that in the velvet chaff the destroyed heads outnumbered those in the Michigan Amber in the proportion of about four to one. Furthermore, the narrow strip of mixed grain intervening showed very much the same feature. I confess that I am unable to detect any reason for this difference in the severity of the attack other than in the nature of the straw; that of the velvet chaff being under ordinary conditions a few days earlier in maturing, yet it is known among farmers as possessing a softer straw than the Michigan Amber, which fact presupposes the tissue of the stem immediately above the upper joint to be to a corresponding degree more tender and juicy at the time of oviposition by the females.

THE WESTERN STRIPED CUTWORM.

(*Agrotis herilis* Grote.)

The present year has been conspicuous for the severity of cutworm attacks, especially in corn-fields, the most abundant and pernicious species thus engaged being the one under consideration. Ordinarily we look for these dusky, semi-subterranean destroyers in fields of recently broken grass lands, but this season their ravages were not to be limited by any such proscribed bounds, and old lands suffered with the new.

On the 28th of May I visited a field of corn a few miles out of the city of La Fayette, which had been nearly ruined by cutworms, notwithstanding the present was the seventh consecutive crop of corn which had been planted on this ground. In fact, so abundant were the pests, that from a mass of dried weeds and earth, covering a couple of square feet, and which had been left by the plows, I took 36 individuals, and a clod a few inches away concealed 5 more; the whole number evidently belonging to the same species.

The only apparent cause for this congregating in corn-fields, and in this one in particular, is that during the ovipositing season last sum-

mer the grass-lands in this section were withering and drying up under a terrible drought. This corn-field had been poorly cultivated and the lower portions grew up to grass and weeds, thereby forming a more desirable locality for the females to lay their eggs. In other words, the drought of August and September of 1888 drove the moths to the corn-fields to oviposit, and the abundance of worms this year is the result.

The thirty-six cutworms collected on May 28 were taken home and immediately placed in a breeding cage, being fed upon clover during the few days they remained above ground. The first moth appeared on August 23, followed by others up to the 26th, when a medium-sized *Anthrax* was also observed in the cage. As nothing could be found in the literature at hand to indicate that any of the *Bombyliidæ* had ever been reared from lepidopterous larvæ, in this country, its occurrence was supposed to be accidental, the larva having been in some way taken up with the earth in the cage. It was followed, however, on September 1 by a second adult, and two more appeared on the 4th, others appearing up to the 9th, when all doubts as to the host of these flies were removed by two adults issuing from a couple of chrysalids laying on the surface of the soil, the *Anthrax* leaving their empty pupa cases protruding half way out from the chrysalids of the *Agrotis*. The flies may be roughly described as from 10 to 13^{mm} in length, black, densely covered with fine silky hairs, those on præscutum and episternum of mesothorax, basal half of abdomen, and tuft on posterior margin of penultimate segment being silvery white, changing to yellowish, especially on the shoulders.

The same species was frequently observed, near the middle of September, hovering about over the surface of the ground under trees recently denuded of their foliage by the larvæ of *Datana ministra*, thereby conveying the impression that they might be parasitic upon that species also.

As nothing whatever is known of the time and method of oviposition of the *Bombyliidæ*, it will only be safe to say that the eggs were deposited either on or about the bodies of these cutworms prior to the 28th of May.

In a most excellent paper by Dr. Riley, in the Second Report U. S. Entomological Commission, pp. 262–269, larvæ of an allied species is mentioned as infesting the egg-pods of *Caloptenus spretus*, being found of different sizes during most of the year. From rearing this species, *Systœchus oreas*, O. S., Dr. Riley concludes that, "as a rule, but one year is required for full development;" but there is great irregularity and a tendency to retardation of such development.

Should the species under consideration be of similar habits, the eggs would, as a matter of necessity, have been deposited last fall, the larvæ wintering over in the bodies of these cutworms, which are not usually over half grown at the beginning of winter. If this be true it is certainly an interesting feature of parasitism.

THE ARMY WORM.

(*Leucania unipuncta* Haw.)

With the rapidly increasing area of low, wet lands, which are being under-drained and brought into cultivation, the natural haunts of this species becomes more and more encroached upon. What the ultimate effect of this change of natural conditions will amount to in the future, and whether or not it will have a tendency to scatter the spring brood of moths in their selection of places of oviposition, only future years will answer. In accordance with the characteristic partiality of the species for low, damp localities, the outbreaks in Indiana this year have been restricted to the lower laying and flatter portions of the State, where a very considerable part of the land remains undrained, except by open ditches. While this state of affairs has been going on, the fact that dry seasons are favorable to the increase of the species has been amply demonstrated. The last two summers have been unusually dry, and the spring of the present year, up to May 30, was exceedingly dry, making three consecutive years of drought, during all of which this pest has appeared in various portions of the State, the maximum injury being caused the present summer. During this period, also, we have had wet springs and dry summers and dry springs and wet summers, proving conclusively that wet weather has little if any direct influence upon the increase or decrease of numbers. In short, it is difficult to resist the suspicion that this ebb and flow, so to speak, may be due more to the fluctuation of natural enemies than to the direct influence of meteorological conditions, severe droughts excepted.

In the vicinity of Princeton, Ind., where considerable damage was done last year, there occurred this season only one weak, aborted outbreak, in a small field of rank growing timothy grass. A slight attack three years ago on the borders of a large tract of swampy land in the vicinity of La Porte, Ind., was not followed by others, either last season or this, although this year similar and more serious outbreaks occurred in that immediate section of the State, and within a few miles of the same locality. Such phenomena can not be wholly attributed to meteorological conditions, most certainly. The most efficient parasites of the army-worm are two species of *Tachinæ*, and we have reared both plentifully this season. The local effects of these parasites is probably more lasting than we are given to suppose. A circumstance came under our observation recently where the attack of a similar species of *Tachina* on the larvæ of *Datana ministra*, infesting an isolated walnut tree, was such that the tree has been free of the caterpillars since 1885. If the effects are equally lasting in the case of the army-worm it will be difficult to foretell their appearance in dangerous localities, even in seasons supposed to be most favorable.

Again, the secret of the power of the army-worm to destroy is in their massing together in endless numbers. Were it not for this they would

not be more destructive than others of the group of cut-worms to which they belong. As stated in the beginning, the prevailing system of underdrainage has at present a tendency to emphasize this gregarious habit by restricting the area of wet grounds.

Whether this will continue to be the case, or whether, after a time, the effect will be to break up the habit of massing into large swarms, and diffuse them into smaller and less destructive colonies, remains yet to be seen.

The heaviest damage has this season, here in Indiana, fallen upon the rye crop, a state of affairs which has excited much comment among farmers. The reasons for this seemingly general selection of this crop, for depredation by the worms, are (1) on account of its hardy nature, rye is often sown on these swampy or mucky lands, as it withstands the weather there better than any other crop; and (2) by nature it is a rank grower, and, therefore, a field in spring presents to the female moth all the requirements of a suitable locality to place her eggs, viz, where her progeny will have an abundant supply of succulent food, in a damp place and shaded from the direct rays of the sun. In all fields of rye examined which have been ravaged by the army-worm, the latter were found to have originated in the fields themselves and had not migrated to them. Cases were not uncommon, however, where the worms originated in grass lands and from thence invaded fields of wheat and oats.

The prospect of controlling the outbreaks of the army-worm in the future seems encouraging, provided the farmer is perfectly familiar with their habits. Much of the damage done might be prevented if decided measures were taken at the start. The trouble is that too often the farmer wastes the most precious time in waiting to see what the worms are going to do, and by the time he finds out they are beyond control.

So far as I have been able to learn, where a neighborhood has turned out *en masse*, and taken decisive measures to destroy the worms, little injury has been done. These measures have consisted in ditching around the infested area and either flooding the ditch with water, or otherwise destroying what fell into it, and driving stock over the area inclosed by the ditches, whereby vast numbers of worms were crushed. From pupæ obtained in Fulton County the following parasites were reared: *Ichneumon brevicinctor* Say, *Nemoræa leucaniæ* and *Drymeia* sp?. *Ophion purgatus* Say, also a parasite on *Leucania*, was this year reared from pupa of *Scoliopteryx libatrix*.

THE FALL ARMY-WORM.

(*Laphygma frugiperda* Ab. and Sm.)

In 1885 and again 1889, we found larvæ of this species feeding on the tassels and unfolding leaves of young volunteer corn, late in September, in the vicinity of La Fayette, Ind. In both cases we reared adult

moths from the larvæ, the former appearing during late October. These breedings would seem to indicate that at least some of the fall brood may winter over in the adult stage.

A NEW CUT-WORM.

(*Luperina* (*Hadena*) *stipata* Morr.)

On May 28, while searching for Sphenophorus in a field of corn planted on recently broken prairie sod, a depredator was found which both in itself and method of work was new to me. Though the young corn was at the time several inches high, many of the plants were withering and dying, but aside from this neither the plant itself nor the earth about it gave the least indication of the presence or nature of the destroyer. Digging down in the earth about the hills, one or more of the shoots would be found wholly or partly eaten off, either near or a short distance above the seed, and in a single instance the seed kernel itself was observed being eaten. The method of attack appeared to be to first eat into the tender stem and then to burrow upward, after the manner of *Gortyna nitela*, above ground, and as soon as one plant was consumed another was attacked, without the worm coming to the surface. The larvæ were rather slender, from half to three-fourths of an inch long, quite active and in general coloration somewhat resembling the larvæ of *Crambus zeellus*, but being more robust, spinning no web and living wholly under ground. Larvæ taken from the field June 8, continued feeding in confinement until early in July, and the moths appeared in the breeding cage about the 25th of the same month. On account of being absent from home much of the time between the middle of June and 20th of July, it was impossible for me to get exact dates.

My own collections of larvæ were from recently broken prairie sod only, none being found in timothy or blue-grass sod adjoining. Farmers in the vicinity of this field state, however, that the worm does work in timothy sod, and serious damage in a fall-plowed field was attributed to their work.

Under date of June 15, Mr. J. C. Besom, of Anderson, Madison County, Ind., wrote me that a kind of Cut-worm had appeared in his fields which he had never observed before. They began working on clover sod, about May 10, and destroyed the first planting of corn, and were at the date of writing making way with the second planting, working underground and eating the plants from the roots upward to the surface of the ground.

The larvæ are whitish, striped on the back with brown, head and cervical shield yellowish. Their general form is more slender and longer than that of ordinary cut-worms, being nearer that of *Gortyna*.

(*Crambus zeellus* et al.)

While natural enemies of the larvæ of various species of *Crambus* have been recorded, those attacking the adult moths are, so far as published record goes, rather limited in point of numbers.

One of the probable enemies of our corn-destroying *Crambus* is a Neuropter, a *Bittacus* near *stigmaterus*. During August Mr. W. O. Pritz brought me an example which he had observed to attack a female moth, chasing her about, finally worrying her down and killing her. The remains of the moth when brought to me were too much mutilated to determine.

Mr. J. N. Latta, of Haw Patch, Ind., tells me that the moths of *Crambus laquealellus*, which I observed in abundance in his yard, were destroyed in great numbers by the Wood Pewee, *Contopus virens* L.

THE WHITE GRUB.

(*Lachnosterna spp.* ?)

The present season has been marked by the most serious depredations of these pests that has occurred for many years. Pastures, meadows, and corn-fields have suffered in some instances to the extent of 75 per cent. of the crop. Fields this season devoted to corn, but for thirty years previous under cultivation, continuously producing some one of the cereal grains, have been very seriously damaged, large areas of the corn withering and dying in the hill during August and September, from five to twenty grubs being found in and about a single hill. As early as May 13, at the Experiment Station, they were destroying young barley growing on a plot of ground which had produced a crop of this grain for the six preceding years. Adjoining this plot of barley was another which had been devoted to oats during the same period, but which was only slightly attacked. A precisely similar plot of buckwheat, which had produced the same crop for the same period, was found also invaded, and on July 24 the grubs were found in the act of cutting off the plants, now several inches in height.

A number of experiments were made with various substances with a view of determining the possibility of destroying the grubs without injury to the plant infested. Corn was the plant used in these experiments, being at the time the most convenient to obtain; the substances used, however, had they been ever so effective, could hardly be applied with practical advantage by the extensive farmer.

Experiment No. 1.—Placed a grub about the roots of a single plant on May 14; two days later, applied a sufficient amount of air-slaked lime to the surface of the ground to cover very lightly, watering thoroughly.

Result, May 22, plant killed but the grub uninjured.

Experiment No. 2.—Placed grub about roots of plant May 14; two days later applied table salt in solution at rate of 235 pounds per acre.

Result, five days later, plant and grub alike uninjured. A second application killed the plant but not the grub.

Experiment No. 3.—Placed grub about root of plant May 14; two days later applied fresh unleached ashes to surface of ground in sufficient quantity to cover lightly.

Result, five days after, plant and grub alike uninjured.

Experiment No. 4.—Single grub placed about roots of plant May 14; two days later applied 4 ounces gas-tar water.

Result, next day, plant killed; grub uninjured.

Experiment No. 5.—Single grub placed about roots of plant May 14; two days after earth about roots thoroughly saturated with tobacco water.

Result, five days after, plant and grub alike uninjured.

Experiment No. 6.—Single grub placed about roots of plant May 14; two days later applied 1 drachm Diamond soluble bone* in solution.

Result, six days later, plant and grub unaffected by application; grub eating off the roots.

Experiment No. 7.—Grub placed about roots of plant May 14; two days later ¼ ounce carbon bisulphide poured in hole made in earth near roots and immediately refilled with earth.

Result, second day after, plant and grub both dead.

Experiment No. 8.—Single grub placed about roots of plant May 14; two days after thoroughly saturated the soil with ammonial water of 1.025 specific gravity, 2.68 per cent. ammonia reduced 75 per cent.

Result, three days after, plant killed but the grub was alive and active.

Experiment No. 9.*—One grub placed about roots of plant May 22 and one drachm of phosphate salt applied in solution to the soil about roots. On 23d, corn was being destroyed by the grub and the next day the plant was wholly eaten off while his grubship appeared uninjured.

Experiment No. 10.†—Single grub placed about roots of plant and one drachm of fertilizing salt applied in solution to soil about roots.

Result, two days later, plant withering, grub all right but had not fed from plant which soon died.

Experiment No. 11.—Grub placed about roots of plant May 22; soil at once saturated with solution of powdered Pyrethrum and water; 1 ounce of powder to gallon of water.

Result, two days later, neither plant nor grub injured.

Experiment No. 12.—Grub placed about roots of plant May 22; next day the soil about the roots was drenched with decoction of Burdock leaves.

* Analysis:

	Per cent.
Available phosphoric acid	13 to 15
Insoluble phosphoric acid	1 to 3
Total	15 to 17
Ammonia	½ to 1

† The phosphate salt and fertilizing salt used in experiments 9, 10, and 14, were sent to the Indiana experiment station by the manufacturer, E. S. Fitch, Bay City, Mich.

Result, two days later, plant untouched ; grub active, but seemingly unaffected by application.

Experiment No. 13.—October 6, earth in field in the vicinity of wheat plants being destroyed by white grub, thoroughly drenched with decoction of Burdock leaves.

Result of examination on October 14: The grub was found a short distance from the plants uninjured, it having evidently destroyed several after application of liquid.

Experiment No. 14.—October 3, earth about wheat plants, being destroyed in field by white grub, thickly covered with fertilizing salt and drenched with water.

Result of examination October 14 exactly as in the preceding, except that the grub was at a greater distance from plants.

Up to the present time, no Dipterous parasite has been recorded as preying upon white grubs, as the subterranean habits of the pest contributes to its protection in this respect. There is, however, pretty good evidence that there is at least one species of fly which exists to some extent in holding these grubs in check. On September 21, while

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who advertises both as not only being excellent fertilizers, but also very destructive to insect life, especially chinch-bugs and cut-worms.

The following analyses were kindly made for me by Prof. Henry A. Huston, chemist of Indiana experiment station:

I. *Phosphate salt.*

A. Qualitative analysis.

Bases present:	Acids present:
Calcium,	Hydrochloric,
Sodium,	Sulphuric,
Iron, trace,	Carbonic,
Aluminium, trace,	Silicic, trace,
Magnesium, trace,	Phosphoric, trace.
Organic matter, trace.	

Principal constituents: Common salt, gypsum, carbonate of lime.

B. Per cent. phosphoric acid present, .03.

II. *Fertilizing salt.*

A. Qualitative analysis.

Bases present:	Acids present:
Sodium,	Hydrochloric,
Calcium, trace,	Sulphuric, trace,
Organic matter, trace,	Silicic, trace.
Phosphoric, slight trace.	

Chief constituent: Common salt.

B. Quantitative analysis.

	Per cent.
Salt (NaCl)	97.70
Gypsum (CaSo)	.44
Insoluble matter	.47
Moisture	1.09
Soluble organic matter and loss	.30
Total	100.00

Samples drawn at experiment station from full sacks, special care being taken to insure fair samples. Neither of these samples contain an appreciable amount of phosphoric acid, potash, or nitrogen.

collecting material for experimentation, in a field seriously damaged by grubs, we found a hill of corn, which, though it contained none of the depredators, bore every evidence of having been destroyed by them, as other hills in a similar condition about it contained from 5 to 10 individuals. Instead, however, a larva of a species of *Erax*, near *bastardi*, was found. As the larvæ of *Erax* are known to be carnivorous, we can only conclude that the one found had made way with the grubs, but not until after the latter had destroyed the corn.

THE VARYING ANOMALA.

(*Anomala varians*, Fabr.).

The only record of this species, as a grain destroying insect occurs in the report of the Commissioner of Agriculture for 1884, p. 412, where Mr. Eugene F. Barns, of Marion, Marion County, Kans., reported the beetle as working serious damage to wheat in the field during the month of June, destroying 1,000 bushels for one farmer.

These beetles occur generally over the State of Indiana, and we have frequently met them hovering on heads of wheat in the field, but never remarked any serious injury. In this State the adult insects are preyed upon by one of the *Asilidæ*, *Laphria tergissa* Say, and we have several times caught these flies on wing with one of the beetles in their clutches, their beak puncturing the body of their victim.

THE WHEAT WIRE-WORM.

(*Agriotes mancus*, Say.)

A number of experiments were made with a view of learning the effect of the applications of salt, as against the larvæ of this species.

The method employed was to place a number of kernels of corn in earthen pots, and transport larvæ from the fields, where they were engaged in destroying wheat, placing them among the corn in these pots, the salt being applied in different quantities to the surface of the ground.

Experiment No. 1.—April 26, six kernels of corn, and two wire-worms nearly full grown, were placed together in a pot filled with earth, the latter being saturated with water from beneath. Common barrel salt was then applied to the surface of the soil, at the rate of 940 pounds to the acre. May 1, watered from above.

Result, the pot was examined May 7, and both worms found unaffected, they having in the meantime eaten nearly all of the corn, the uninjured kernels failing to germinate.

Experiment No. 2.—This was made at the same time as No. 1, all conditions being the same, except that salt was applied at the rate of 470 pounds per acre.

Result the same as in experiment No. 1.

Experiment No. 3.—May 7, placed three of the larvæ used in the preceding experiments and one fresh from the field, with corn in pot of earth, saturating the latter from below, and covering surface with salt in the proportion of 24,500 pounds per acre.

Result five days later; the worms were alive and as active as they ever were. Corn slightly eaten, but none showing any indication of growing, while kernels from same ear planted in unsalted soil were sprouted. The corn used in all experiments was from the same ear.

Drasterius elegans Fab.

The larva of this species has been mentioned in my previous reports as destroying other insects, and themselves injuring young corn. In the present instance they were found exceedingly abundant, on November 15, near New Castle, Ind., where they were evidently working seri, ous injury to a field of young wheat, sown in growing corn about September 5. This field had produced three consecutive crops of wheat then the present crop of corn, among which the young wheat was growing. It was true the wheat was seriously infested by Hessian fly, and therefore the question may arise as to whether the worms were not destroying these; but the damage to the field was by far too great to have been done by the fly alone, and many of the plants had been eaten off below the ground.

With this new revelation regarding their food habits, it seems probable that a part of the wire-worm injuries to wheat sown among corn may be due to this species, instead of the preceding.

THE TWELVE-SPOTTED DIABROTICA.

(*Diabrotica 12-punctata.*)

The adults of this species have been observed in greater abundance than ever before. Gardens and fields have been literally overrun with them. The sexes were observed pairing as early as the 17th of April, thereby promising larvæ sufficiently early to attack young corn, even though planted at the usual time. The list of food plants has this season been observed to include the following, not previously reported: Wheat, cabbage, cauliflower, and beans; an adult was also observed feeding on volunteer oats December 14.

THE SWAMP SPHENOPHORUS.

(*Sphenophorus ochreus* Lec.)

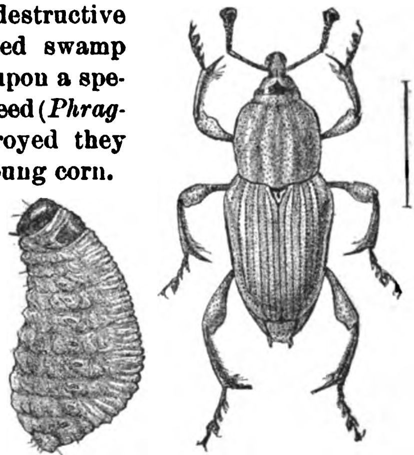
Few insects afford a better illustration of the fact that a comparatively harmless species may, by force of circumstances, suddenly become extremely injurious. Known to the entomologist since 1858, and by no means a rare insect, its habits unstudied because of its secluded haunts and valueless food plant, the species appears to have been overtaken by this progressive decade in agriculture.

The swamp composing the field which formed the basis of the study of this insect was broken up some thirty years ago and two crops of corn raised on it without damage from insect attack, after which, by reason of being too wet, it was allowed to revert back to its original state. Fifteen years ago a second attempt was made to bring it into cultivation, and a single crop of corn raised from a portion of it, this time the insects being noticed, but doing no material injury. The land

was again allowed to go back to its primitive state, and remained thus until last season, when, after being drained, a portion was broken and the remainder brought into cultivation the spring of the present year, with the results here given.

Other fields of swamp land, in the same neighborhood, have suffered in the same manner as this one, but there is at present no information of serious damage until within the last three or four years.

The first published notice of the destructive habits of these insects is found in a brief notice which appeared in several agricultural papers during July, 1888, to the effect that Professor Forbes had found them to be very destructive to corn planted on recently drained swamp lands in Illinois, the adult feeding upon a species of rush (*Scirpus*) and a common reed (*Phragmites*), and when these were destroyed they transferred their attention to the young corn.



a b

FIG. 1.—*Sphenophorus ochreus*: *a*. larva; *b*, adult—enlarged (after Riley.)

On May 23, adult beetles were sent me by Mr. Quincy Earl, a farmer residing near Dayton, Ind., a small village about 8 miles from La Fayette, with the statement that they were destroying his corn.

The beetles were at once confined with corn plants growing in flower pots, the males proceeding to bury their snouts into the tender stems, near the surface of the soil; but the females, to my utter astonishment, burrowed down into the earth, out of sight, and staid there.

Stormy weather prevented my visiting the locality until June 2. The infested field comprised about 75 acres of recently drained swamp land, plowed the present spring, except a small portion which had been devoted to corn the previous year, and the first and second planting destroyed by the beetles. On that portion of the field plowed this spring the young corn was not yet up, but on that portion which had been cultivated last year and planted earlier this year than the newer-plowed portion, the young plants had been totally destroyed, the lack of their natural food having evidently driven the insects to this part of the field, as other fields in the vicinity had not suffered the second year after the ground was first broken, although the first crop had been destroyed. At the time of my visit the beetles were feeding on a species of rush, *Scirpus atrovirens*, Muhl., puncturing the stems just below the surface of the ground and eating out the tender, folded leaves. The sexes were pairing, but I could get no eggs. A large number of adults of both sexes were taken home, as also were specimens of the *Scirpus*, including the roots, which are bulbous and exceedingly hard and compact. These plants were placed in flower-pots, and on each was placed a single pair

of adults. The next day the males were engaged either in pairing or feeding upon the *Scirpus*, but the females, when not paired with the males, had burrowed down into the earth, out of sight.

On a second visit to the infested field, June 11, but few females were to be found above ground. The young corn was coming up well, but being rapidly destroyed by the males and a few females, except where *Scirpus* was growing in sufficient abundance to provide an ample supply of food.

Absence from home, from the middle of June until the middle of July, not only interrupted my observations, but a press of other work prevented my visiting the field again until August 21, both plants and beetles in pots having in the mean time died.

As a result of this last visit I found two adults, one of which was feeding on a small dwarfed stalk of corn and the other on *Scirpus atrovirens*. An examination of the root of this reed revealed full-grown larvæ (Fig. 1, *a*) and fully developed adults still within the bulbs. Other bulbous roots of the same plant gave evidence that the adult had only recently quitted its birthplace. Hurrying home, my plants in the flower pots, long ago dead, dried up and, as I thought, worthless, were examined and in nearly every one was found a fully developed adult, none of which had escaped from the bulbous roots wherein they had developed. (Fig. 2.)

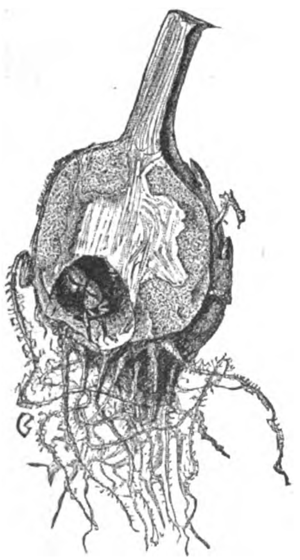


FIG. 2.—Work of *Sphenophorus ochreus* in roots of *Scirpus*—natural size (after Riley).

Still another visit to this field on August 30 confirmed all previous observations, and a single pupa was also found in a bulb of the *Scirpus*.

From what is known of the habits of other species of this genus, coupled with the fact that fields of corn are not attacked by the beetles after the first year following the breaking of the ground, it seems highly improbable that there should be more than one annual brood. This being the case, its life history will likely be as follows: The insect hibernates in the adult stage, coming forth from its hiding places in spring, the females depositing their eggs during May and June in the roots of *Scirpus*. The larvæ hatching from these develop to adults and emerge in about three months.

From the vast differences existing between the plant in which the species breeds and that of the corn plant, the great improbability of the insect ever breeding in corn will at once be seen. The whole problem of prevention seems to settle in the destruction of these reeds, root and stem, the season prior to devoting the ground to corn. The eggs are as a rule deposited in bulbs formed the preceding year, and

we have found healthy adults in bulbs after the latter had been thrown out by the plow and lain in the sun for over a month. We have also found them developing in bulbs in ground plowed in May and again in July, indicating that little or nothing can be accomplished by sum mer fallow.

The most practical and probably the most effective method of destroying the food plant of the pest is to sow rye or some other crop on the land the first season after breaking.

THE CHINCH BUG.

(*Blissus leucopterus* Say.)

The history and distribution of the Chinch Bug in Indiana offers some problems not only very perplexing but exceedingly difficult to solve. In fact, we shall here make no attempt toward a solution, but rather to separate a few of the many complex elements which are thought to influence the distribution and numbers of the pest, and to some extent at least indicate how far they may be considered or perhaps eliminated entirely from any independent relation to the subject, thereby affording aid to the future investigator.

It is well known that although Thomas Say, at the time he described the species, was residing at New Harmony, Indiana, nevertheless his description was drawn from a single specimen taken by himself on the Eastern Shore of Virginia, and so far as we know he may have died ignorant of its occurrence in his own or any of the adjoining States.

Recently, Professor Forbes has collected some data showing that the species was destructively abundant in Edwards County, Illinois, as early as 1828, and was also observed in Richland County in 1823.

Strictly in accordance with the above, while that portion of Illinois lying adjacent to Indiana, separated only by the Wabash River, has suffered again and again through the ravages of the Chinch Bug, crops on the Indiana side have not often suffered from any extensive or widespread ravages of the pest. Not only this, but at the present time the worst infested portion of Indiana is composed of those counties whose western border is the Wabash River, which separates them from Illinois, and from whence the insect occurs in continually diminishing numbers northward and eastward until we reach the northern counties of La Porte, St. Joseph, Elkhart, La Grange and Steuben, where its depredations are almost entirely unknown.* Indeed, during the years when they are the most numerous elsewhere, I have found them in these counties only with difficulty, and few of the farmers know what the insect is like. In almost exactly the same latitude in De Kalb County, Illinois, within 60 miles of Lake Michigan, they have been a serious pest since 1855.

* The only exception known to me was in Elkhart County, where they were reported to Mr. J. R. Dodge, Statistician of the Department of Agriculture in 1887. (See Bull. 17, U. S. Dept. Agri., Div. Ent., p 9.) Mr. Dodge has very kindly looked up this matter, and writes me that these bugs were only reported from one locality in very limited numbers and did no appreciable damage.—F. M. W.

A line drawn from the northwestern corner of Indiana diagonally across the State to the Ohio line, at the southeast corner of Jay County, will divide from the remainder of the State nearly all of twenty-four counties over which the Chinch Bug is either unknown or occurs in too limited numbers to cause serious damage. These are the counties enumerated in Tables A and B. As the numbers of counties from which I have information of serious and wide-spread damage does not amount to twenty-four, I have added others, in which we have observed considerable numbers of Chinch Bugs, and filled out the number with counties situated in the infested district. These are enumerated in Tables C and D.

TABLE A.—*Acreage of various grains produced in* 1887 *throughout the area over which Chinch Bugs do not occur in destructive numbers.*

Counties.	Wheat.	Oats.	Rye.	Barley.	Total small grain.	Corn.	Excess of small grain over corn.
Adams	26,936	9,142	255	35	36,368	30,257	+ 6,111
Allen	48,362	25,687	2,065	101	76,215	42,004	+34,211
Blackford	12,543	2,544	196	41	15,324	16,000	— 676
De Kalb	30,097	13,390	211	157	43,855	22,135	+21,720
Elkhart	44,896	15,207	705	90	60,898	35,145	+25,753
Fulton	29,903	5,684	390	35	36,012	25,827	+10,185
Grant	42,077	5,455	347	147	48,026	49,225	— 1,199
Huntington	34,888	10,693	800	195	46,576	38,145	+ 8,431
Jay	29,588	8,766	275	145	38,774	39,656	— 882
Kosciusko	42,268	13,274	240	162	55,944	40,065	+15,879
LaGrange	36,903	9,818	873	37	47,631	28,292	+19,339
Lake	2,808	26,690	1,284	275	31,057	30,637	+ 420
La Porte	43,904	15,054	802	335	60,095	39,690	+20,405
Marshall	35,062	10,145	1,244	186	47,637	33,238	+14,399
Miami	44,212	7,919	139	168	52,438	42,301	+10,137
Noble	38,797	12,345	120	44	51,306	29,452	+21,854
Porter	15,312	16,365	1,026	236	32,939	21,042	+11,897
Pulaski	19,267	7,828	1,570	394	29,059	23,686	+ 5,373
Starke	3,591	2,916	1,657	298	8,462	7,911	+ 551
Steuben	27,414	9,253	219	310	37,196	22,200	+14,996
St. Joseph	41,525	11,482	440	30	53,477	30,698	+22,779
Wabash	41,109	8,391	115	149	49,764	45,638	+ 4,126
Wells	32,301	6,196	572	54	39,123	39,322	— 199
Whitley	25,633	9,727	95	45	35,500	24,753	+10,747

TABLE B.—*Acreage of various grains produced in* 1888 *throughout the area over which Chinch Bugs do not occur in destructive numbers.*

Adams	23,130	16,818	249	51	40,248	31,417	+8,831
Allen	50,469	27,228	1,895	172	78,764	43,775	+34,989
Blackford	11,057	3,280	253	140	14,730	16,633	—1,903
De Kalb	28,145	14,249	138	169	42,701	25,474	+17,227
Elkhart	43,818	14,783	1,013	78	59,692	36,663	+23,029
Fulton	33,976	6,306	267	12	40,561	29,795	+10,766
Grant	38,808	5,593	316	201	44,918	48,581	—3,663
Huntington	32,639	10,990	218	186	44,033	40,218	+3,815
Jay	25,433	9,666	311	160	35,570	40,750	—5,180
Kosciusko	39,878	14,201	334	135	54,548	41,025	+13,523
Lagrange	33,540	10,285	750	55	44,630	30,252	+14,378
Lake	3,874	21,026	1,330	221	26,461	29,510	—3,049
La Porte	40,642	18,033	772	787	60,234	41,345	+18,889
Marshall	33,187	11,095	1,449	271	46,012	37,134	+8,878
Miami	44,250	8,160	126	188	52,724	42,743	+9,981
Noble	37,983	14,336	217	44	52,580	29,915	+22,665
Porter	16,648	17,428	1,593	213	35,882	27,863	+8,019
Pulaski	17,007	3,407	1,633	282	29,339	26,232	+3,097
Starke	3,965	3,476	1,696	237	9,374	8,633	+741
Steuben	25,944	10,288	310	317	36,859	21,373	+15,486
St. Joseph	37,602	12,170	642	714	51,128	29,343	+21,785
Wabash	40,202	9,892	183	73	50,350	44,080	+6,270
Wells	28,437	8,352	611	147	37,547	38,009	—462
Whitley	21,789	10,647	65	39	32,540	23,503	+9,037

TABLE C.—*Acreage of various grains produced in 1887 throughout the area over which Chinch Bugs occur sometimes in destructive numbers.*

Counties.	Wheat.	Oats.	Rye.	Barley.	Other small grain.	Corn.	Excess of small grain over corn.
Benton	1,592	35,529	390	125	38,036	71,714	—33,678
Clay*	22,610	9,963	160	211	32,944	26,447	+6,497
Crawford*	7,513	9,389	25	....	16,927	15,491	+1,436
Daviess	40,186	10,575	340	42	51,143	39,472	+11,671
Dubois*	24,527	10,950	20	87	35,584	22,042	+13,542
Gibson*	72,513	5,740	386	31	78,670	45,108	+33,562
Green	24,943	11,930	239	178	37,290	34,141	+3,149
Jackson	27,584	14,733	297	45	42,659	42,633	+26
Knox*	48,483	6,426	207	68	55,184	47,331	+7,853
Lawrence	11,423	14,395	136	51	26,005	25,228	+777
Martin	15,740	7,766	136	191	23,833	21,493	+2,440
Monroe	9,505	9,399	35	40	18,979	16,462	+2,517
Orange	12,322	17,708	84	96	30,210	26,836	+3,374
Owen	14,343	9,705	91	20	24,159	16,910	+7,249
Parke	33,828	9,426	297	66	43,617	39,751	+3,866
Pike	35,698	9,080	83	107	44,968	30,095	+14,873
Posey*	60,902	6,600	120	47	67,669	38,979	+28,690
Putnam	33,544	7,613	117	96	41,370	37,006	+4,364
Sullivan*	33,624	10,059	826	55	44,564	44,109	+455
Tippecanoe	49,330	14,657	544	120	64,660	79,497	—14,837
Vermillion	30,274	6,724	352	98	37,448	35,549	+1,899
Vigo	35,738	13,096	694	217	49,745	50,082	—337
Warrick*	30,088	9,609	62	40	39,799	33,171	+6,628
Washington*	17,245	19,028	77	68	36,418	30,206	+6,212

TABLE D.—*Acreage of various grains produced in 1888 throughout the area over which Chinch Bugs occur sometimes in destructive numbers.*

Benton	2,470	36,801	372	81	39,724	84,751	—45,027
Clay*	22,136	10,720	178	150	33,184	28,100	+5,084
Crawford*	9,527	7,216	13	10	16,766	14,502	+2,264
Daviess	39,049	11,194	280	75	50,598	39,259	+11,339
Dubois*	26,414	10,168	48	128	36,758	22,799	+13,959
Gibson*	68,640	5,606	466	116	74,828	48,280	+26,548
Green	30,962	12,627	253	84	43,926	35,745	+8,181
Jackson	27,425	14,135	254	34	41,848	43,007	—1,159
Knox*	47,798	6,869	222	163	55,058	54,001	+1,051
Lawrence	10,559	14,392	208	79	25,238	31,666	—6,328
Martin	14,450	8,797	124	126	23,497	20,928	+2,569
Monroe	10,147	8,500	64	22	18,733	16,241	+2,492
Orange	13,446	15,246	94	78	28,864	25,406	+3,458
Owen	13,329	10,402	82	43	23,856	17,422	+6,434
Parke	33,523	9,718	256	57	43,554	44,771	—1,217
Pike	30,934	10,154	54	106	41,248	32,062	+9,186
Posey*	59,006	7,465	108	39	66,618	46,711	+19,907
Putnam	32,139	8,194	131	74	40,538	39,358	+1,180
Sullivan*	29,377	11,279	798	68	41,522	45,808	—4,286
Tippecanoe	53,000	15,313	570	129	69,012	82,611	—13,599
Vermillion	29,985	7,710	439	76	38,210	35,444	+2,766
Vigo	36,157	14,327	557	203	51,244	52,084	—840
Warrick*	30,562	10,191	144	57	40,954	34,589	+6,365
Washington*	18,465	19,922	39	46	38,472	34,911	+3,561

* Counties marked with asterisk (*) are those in which Chinch Bugs have been reported in destructive numbers.

Much has been said of late of the influence which the cultivation of wheat and other grains has on the numbers and distribution of the Chinch Bug. Tables A, B, C, and D, here given show the acreage of each of the cereal grains in forty-eight counties for the years 1887 and 1888. It will be observed that among the uninfested counties there are but four which had a greater area of small grain than of corn in 1887 and in 1888. In 1887, in eleven of these same counties, the area of wheat exceeded that of corn, in six of which counties the Chinch Bug

is unheard of. Practically the same state of affairs existed in 1888, both as to crop and bugs. In the twelve counties more or less infested with bugs in 1887, four had a larger area of corn than of small grain, and all but seven showed a greater area of corn than wheat. In 1888 only three had a greater area devoted to wheat than corn, and six had a greater area of corn than of small grains. It will be observed that Sullivan County, which probably suffers from Chinch Bug injury as bad as any portion of the State, is one of these. It appears therefore that the nature of the crop has of itself nothing to do with the distribution of the Chinch Bug in Indiana.

TABLE E.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Princeton, Gibson County, Ind., latitude 38° 23′ N., during the months of April, May, and June, for the years* 1885, 1886, 1887, 1888, *and* 1889.

Year.	April.		May.		June.	
	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.
1885	3.70	53.5	2.30	61.5	5.90	71.9
1886	3.50	55.3	2.10	66.1	4.90	71.3
1887	2.30	53.2	6.10	68.0	.10	74.3
1888	1.50	55.3	1.95	63.5	2.50	76.7
1889	.80	55.2	4.40	64.4	3.60	70.7

TABLE F.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Angola, Steuben County, Ind., latitude* 41° 37′ *N., during the months of April, May, and June, for the years* 1885, 1886, 1887, 1888, *and* 1889.

1885	4.35	45.6	6.95	56.9	4.32	66.9
1886	2.77	52.5	3.49	63.5	4.16	67.2
1887	1.12	45.2	1.95	70.8	5.24	71.2
1888	1.64	46.5	3.75	61.9	5.16	70.6
1889	1.19	49.2	5.25	61.4	3.50	68.5

TABLE G.—*Total amount, in inches and tenths, of precipitation and mean temperature, in degrees and tenths, at Sandwich, De Kalb County, Ill., latitude* 41° 31′ *N., during the months of April, May, and June of the years* 1885, 1886, 1887, 1888, and 1889.

1885	2.46	46.71	1.30	58.65	2.94	68.95
1886	1.35	56.40	3.06	64.70	1.28	68.82
1887	.57	53.12	1.87	68.55	1.77	75.07
1888	1.70	49.84	5.14	58.72	2.76	72.48
1889	3.15	52.03	3.08	61.71	5.40	68.62

Neither can this unequal distribution be attributed to the interspersion of timber lands among the cultivated fields, as the northern and southern portions are about equally wooded, and, besides, the treeless prairies of the State are not particularly subject to invasions of Chinch-bugs. Low temperature can hardly be held responsible for the phenomenon, as the ravages in more northern localities like Nebraska, northern Iowa, and in Minnesota will attest. Coming northward from the Ohio River, during the season of drought which has occurred each year since 1886, one can not help but admit that the effects of dry

weather are greatest in the southern portion of the State. But the difference between this weather condition is certainly not so marked between Tippecanoe and Benton Counties on the one hand, and La Porte and Lagrange Counties on the other, as to result in a difference in the number of bugs amounting to that between a great abundance and almost none at all. In Tables E, F, and G are given the mean temperature and rain-fall for the months during which these elements most affect the Chinch Bug, and extending over a period of five years.* This is as far back as the Indiana records extend. The records from Princeton, Ind., indicate the meterological conditions during this period in the bug infested area, and those from Angola are a like record of the weather conditions in the region exempt from Chinch Bug attack, while Table G gives the meterological conditions in De Kalb County, northern Illinois, where Chinch Bugs have been abundant since 1855, formerly doing serious damage to spring wheat, and have, since about 1862 (wheat of any sort being no longer grown to any extent), been transferring their attention to the corn crop, but being at present less abundant than in southeastern Indiana or southern Illinois.

From a study of the tables given it will be seen that while the northern Illinois locality had a less rain-fall during the spring and early summer than the northern portion of Indiana, it also had a less amount than had southern Indiana; yet, while Chinch Bugs are more numerous in the Illinois section than in northern Indiana, they are not so abundant as in southern Indiana.

Geologically, the northern portion of Indiana differs from the southeastern portion, the former being Devonian and the latter carboniferous or subcarboniferous. This, however, could have little effect on the Chinch Bug, except, possibly, so far as it influenced the natural flora, especially the grasses. Prof. James Troop, who has made the grasses of Indiana a study, informs me that the following are all, or nearly all, the species found in the southern portion of the State which do not occur in the northern portion: *Uniola latifolia*, *Arundinaria tecta*, *Paspalum fluitans*, *P. læve*, *Panicum prolificum*, *P. anceps*, *P. vicidum*, *Andropogon divisitiflorus*.

From the foregoing it will be seen that to no one of these elements alone, as existing between southwestern Indiana and Illinois on the one hand, and northeastern Indiana, southern Michigan, and northern Ohio on the other, can this immunity from Chinch Bugs in these last localities be traced. Whether the combination of two of these elements, such as dry weather and wheat-growing, is to be held wholly responsible, or whether there is still another potent element, as yet unknown to us, which, either in itself or combined with some other, is the prime cause of the present state of affairs, only future studies can demonstrate.

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* Kindly supplied me by N. E. Ballou, M. D., Ph. D., Sandwich, Ill., for thirty years volunteer signal observer at that place.—F. M. W.

That dry weather during spring and early summer is almost invariably associated with an increase, and wet weather during the same period with a decrease of Chinch Bugs is usually true, but why this is so has never been definitely explained.

The fungoid disease known as *Entomophthora* has, since it was studied by Dr. Shimer, been known to be much more fatal in wet than in dry weather. How far this would prove true, and to what extent the farmer could rely upon this fungus to keep the Chinch Bug in check, gave the incentive for carrying out the following experiments.

Early in July, 1888, a large number of Chinch Bugs, principally pupæ nearing the last molt, were placed in a close glass vessel and kept in a very damp atmosphere and under high temperature. Although kept for two weeks under these conditions we failed to produce the *Entomophthora* among them. This was accepted as evidence that the fungus did not exist in any stage of development here at La Fayette, Ind., although it was reported from an adjoining State.

On July 20, of the present year, we received some dead chinch bugs from Prof. F. H. Snow, of Lawrence, Kans., which were said to be affected by *Entomophthora.* These diseased bugs were placed under glass with living ones from the fields, the latter being provided with food and kept thus confined for fifty-three hours, when the major portion of them were placed on several hills of corn, seriously infested by bugs, the remainder with the dried remains received from Professor Snow being scattered about over a small area of young wheat sown for experiment, and also swarming with young Chinch Bugs. The hills of corn on which the bugs had been placed were isolated from others, equally badly infested, by narrow frames of boards placed on the ground, and the upper edges covered with tar. This last precaution was taken in order to prevent communication with other hills, intended as checks on those used directly in the experiment. The area of young wheat over which infested bugs had been placed was not inclosed, but its limits carefully marked. Five days after, July 27, a single bug was found on one of the isolated hills of corn which had very evidently died from the effects of *Entomophthora*, and by the 30th enough others were found to show that the fungus had fully established itself, and the barriers about the isolated hills were removed. On August 2, dead bugs covered with *Entomophthora* were found in considerable numbers about hills of corn, 25 feet from where the original colonies had been placed, and also throughout and even 55 feet beyond the area of young wheat over which dead and affected bugs had been distributed. Daily observations were now made, but the progress of the disease seemed to come to a stand-still. From the 5th of August up to the 9th it was almost impossible to get sufficient material, outside, to enable me to carry on laboratory experiments. August 13, the spread of *Entomophthora* appeared to have taken on new life, and diseased bugs were becoming much more numerous. August 15, found diseased bugs 172 feet from any place where they had been previously observed. August 20, diseased bugs were very abundant over all of

the area where disease had been distributed, and two days later examples were found a quarter of a mile from the starting point of the disease. Immediately after this, however, another halt, both in the intensity of attack and rapidity with which it spread, due either to the dry weather, or to the fact that the bugs had now all reached the adult stage, and had become diffused over the country, no longer congregating together. From either one or the other, or both of these causes, I lost track of the *Entomophthora* and was not able to again find it in the fields. It seems proper to state here that Chinch Bugs were not at any time excessively abundant. The greatest numbers were in the exact localities where the disease was first distributed, the congregating at these places being brought about by the close proximity to a large number of small experimental plats of wheat, and when this was harvested the bugs collected *en masse* on the corn and young wheat. In connection with these facts, it is also interesting to note that from July 15 to August 31 there were ten days on which rain fell. The dates of these rains and the amount of precipitation is given below:

Date.	Precipitation.	Date.	Precipitation.
	Inches.		*Inches.*
July 17	.02	July 29	.78
19	1.25	30	.50
22	.20	Aug. 9	3.36
23	.04	13	.15
26	.13	14	.02

With a view of learning whether or not there was any difference as regards susceptibility to the attack of *Entomophthora*, between bugs in different stages of development, a series of experiments was begun, as follows:

Young plants of *Setaria glauca* were transplanted to a box, and upon each plant was placed a dead bug covered with the fungus, and also healthy larvæ; larvæ just on the point of pupation; pupæ just prior to reaching the adult stage; and fully developed adults, each stage being placed on separate plants and each covered with a small inverted glass vial numbered by lettering. As checks, another series was prepared like the first in every particular. The soil in the box was kept well moistened, and the plants remained fresh. This experiment was made on August 2, about the time when the attack outside began to diminish in intensity. The following are the results of examinations on the dates indicated, the original experiments being numbered by capitals, and the checks by small letters, thus—A–a, adult; B–b, young larvæ; C–c, older larvæ; D–d, pupæ.

Date.	A.	a.	B.	b.	C.	c.	D.	d.
Aug. 5	Healthy	Healthy	Healthy	Healthy	1 dead	Healthy	1 dead	1 dead.
Aug. 6	1 dead	1 dead	Healthy	Healthy	1 dead	Healthy	3 dead	1 dead.
Aug. 7	All dead	3 dead	3 dead	1 dead	3 dead	1 dead	....	5 dead.
Aug. 16	All dead	All dead	All dead.	All dead	All dead	All dead	All dead	All dead.

On the same day this experiment was begun, a second was also commenced, like the first in every particular except that the healthy bugs used, in experimentation, were exposed to fungus infested individuals for only five hours, and then placed under their respective glasses. As a result on August 15, thirteen days after, none had died, thus strongly indicating that the *Entomophthora* did not exist generally in the fields, and that it could not be communicated during a period of five hours, exposure.

On August 7 a large number of healthy bugs were placed under glass, with a number which had recently died from *Entomophthora*, the moisture in the vessel being absorbed by calcium chloride. A check experiment was also commenced, where the material and the conditions were the same, except the humidity of the atmosphere, care being taken to have the latter as nearly saturated with moisture as possible. August 10, the original experiment was divided and a portion of the healthy bugs removed and placed in a damp environment, the remainder being kept under the original dry conditions. The results on August 22 were as follows. In the original experiment, where the healthy bugs had been continually in dry quarters, not a single bug had died from *Entomophthora*. Not only this, but none of those which had been removed after three days and placed in dry quarters had died, showing that the disease was not contracted and did not develop in healthy bugs, though kept exposed in a dry atmosphere for fifteen days, nor could it be originated by placing, in a damp atmosphere, for twelve days, bugs which had been exposed to contagion for three days in dry quarters. The results with the check experiment were quite different. Within five days after being confined with the *Entomophthora*, the healthy bugs began to die from effects of the disease, and in three days more every one had died from the same cause, their bodies being covered with spores.

Still another experiment was tried which consisted in confining a large number of healthy bugs with others diseased in a damp environment, and when the fungus had destroyed a portion the remainder were divided and a part removed to dry quarters. The result was that while those left in damp confinement continued to die, none of those inclosed in dry environment were destroyed. As the fungus had by this time become distributed over the experiment farm so that I could not tell with certainty whether material from the fields was in a perfectly healthy condition or not, no farther experiments were made in this direction.

From the foregoing it will be observed that the essential element in all of these experiments was an abundance of moisture, without which the *Entomophthora* could neither become established nor flourish after it had gained a footing. Again the extent to which the disease will prove contagious will depend upon the number of bugs. Without great numbers massed together comparatively few would contract the disease. To sum up the matter there is little hope for relief to the farmer from the influence of *Entomophthora*, except when Chinch Bugs

are abundant and massed together in great numbers, and during a period of wet weather. I have succeeded in getting the fungus established at two widely located points in Indiana, and do not consider it at all difficult to introduce in localities where Chinch Bugs are abundant, provided the weather is favorable. But if it is ever utilized by the farmer, which seems to me to be at present a matter of considerable doubt, it will only be after the pest has become very abundant, during the time between the first larval and adult stages and in a wet time. After the *Entomophthora* has been introduced into a certain field it will become diffused only in proportion as the bugs travel about and healthy bugs come in contact with spores from those which have died from the disease. This will not be very great until the pupal stage is reached.

The larvæ of Chinch Bugs seem to in some way understand that while moulting they will be well nigh helpless, and hence hide themselves away in vast numbers in secluded places. Under such conditions the spores thrown from diseased bugs would reach a larger number of their fellows. I have found adults but recently moulted affected by the *Entomophthora.* After the bugs acquire wings and scatter themselves over the country, the liability to contagion will be again reduced, unless in case of very severe invasions, where from force of numbers congregating on or about food plants becomes a necessity. Hence, the introduction of the fungus among larvæ will at first proceed but slowly, and only in extreme cases and under favorable conditions can it be expected to proceed much more rapidly among adult bugs. In short, the only way that this fungoid disease seems capable of being employed in agriculture is by the establishment of some central propagating station to which farmers can apply and receive an abundant supply of infested bugs on short notice. By this means they could take advantage of a rainy period of a week or ten days, and, if they can contrive by sowing plats of millet and Hungarian to mass the bugs in certain localities about their fields, they might accomplish something towards warding off an invasion. But the possibility of overcoming an invasion after it is fully under way, as is almost sure to be the case during a dry season, it must be confessed is not very encouraging. My failure after repeated experiments to produce this *Entomophthora* in the vicinity of Lafayette without the importation of germs is decidedly against the theory that might be advanced that the northeastern portion of the State was kept free of destructive invasions by reason of this disease brought about by wet weather. There is as yet no reason to believe that the disease has ever existed in that section of the State.

Before leaving the subject it will be proper to state that in my experiments a larva of *Chrysopa* was introduced by accident and passed through the larval stage, feeding continually on bugs dying from the effects of the fungus.

After harvest the Chinch Bugs, as usual, transferred their attention to various grasses which were growing up among the stubble, more especially *Setaria* and *Panicum,* but as these succumbed to their contin-

ned attacks they transferred their attention to Timothy, and appeared to subsist equally well upon it.

At the date of wheat-harvesting, fields were swarming with a species of lady beetle, *Coccinella 9-notata*, they having become excessively abundant by reason of the great numbers of the Grain Aphis, and as these disappeared the Coccinella was obliged to scatter themselves about and seek other food. As large numbers were found on stalks of growing corn infested by chinch-bugs, it seemed proper to determine the object of attraction to such places. The problem was in part solved by the fact that wherever great numbers of Chinch Bugs had punctured the corn plants the sap would exude from these punctured spots, and there the beetles would be found, singly or in groups of two or three, engaged in feeding upon the sap. Beetles placed under glass with a great number of Chinch Bugs refused to prey upon the latter, even when brought nearly to the point of starvation.

While searching under the sheaths of corn on several occasions larvæ and pupæ of a Syrphus fly were found, in many cases, right among the masses of young bugs. From some of these pupæ thus obtained we reared adults of *Pipiza pulchella*. Whether this species will ultimately prove to be an enemy of the Chinch Bug, it is too much to say, but the larvæ found by me could only have fed upon bugs or exuding sap, as they were near the roots of the corn where no pollen had collected.

THE GRAIN APHIS.

(*Siphonophora avenæ* Fab.)

Probably no insect has appeared in the State of Indiana for many years which caused such a general commotion among wheat-growers, and which worked so little damage, considering, its numbers, as this.

Occurring every year in greater or less numbers, and having been frequently sent us by farmers, we were not at all surprised to receive specimens from Gallatin County, Ill., on May 27, and also a few days later from our aged friend Dr. Richard Owen, of New Harmony, Posey County, Ind. Probably about May 20 can be set down as the date of appearance, in numbers to attract attention in the extreme southern part of the State, the invasion terminating in the extreme northern portion about the 1st of July.

That the outbreak, which was probably the most severe since 1861 and 1862, should reach the magnitude that it did, both in point of numbers and area infested, was a surprise to me, as the preceding November had been spent by myself in traveling about, visiting the wheat fields of various portions of the State, these insects then being observed in no greater numbers than was usual at that season of the year. The winter following was an extremely mild one, which, taken with the statement of Dr. Cyrus Thomas,* that the insect passes the winter on grain plants in the fields, might lead to a misunderstanding as to the actual effect of mild winters.

* Eighth Rep. St. Ent. Ill., 1879, p. 53.

The winters of 1861 and 1862, the years of the serious outbreaks in New York and New England, though not particularly severe in the sections above mentioned, were by no means noted for mildness. It seems doubtful, therefore, if the causes leading to the invasion of the present year would carry us farther back than the spring months, a statement strongly substantiated by our own observation.

Starting, then, with the month of March we search for some meteorological element which might affect the increase of the Grain Aphis, and which appears both in the present season and also in 1861 and 1862.

TABLE H.—*General weather conditions in various localities during years of great abundance of Grain Aphis.*

Locality.	Year.	March.	April.	May.	June.
New York and New England	1861	Cool	Cool	Cool	Cool.
		Average.	Wet	Wet	Dry.
	1862	Cool	Cool	Cool	Cool.
		Wet	Wet	Dry	Dry.
Indiana	1889	Warm	Warm	Cool	Cool.
		Dry	Dry	Dry	Wet.
Western New York	1889				Cool.
					Wet.

The weather conditions as relating to New York and New England for 1861 and 1862, as given in Table H are based upon reports contained in the Country Gentleman for these years. Those for Indiana are based on the reports of the State Weather Service, and the data for western New York, for 1889, was given me by Prof. James Troop, Horticulturalist of the Indiana Experiment Station, who visited Livingston County in July.

From Table I, taken from Indiana Weather Service reports, it will be observed that during March and April the temperature was considerably above the normal, with the precipitation during this time below the average. On the other hand, the temperature of the months of May and June was much below the normal, with, as indicated by Table I, precipitation above the average. By referring to Table K, however, it will be observed that about half of the precipitation of May fell on the 29th and 30th of the month, thereby changing the apparent state of affairs, and practically throwing May into the dry period.

We have stated that the outbreak of the grain Aphis became conspicuous in southern Indiana and Illinois in May. It is also true that they reached their maximum numbers during the very last of this month and early June. In other words, they appeared during cool, dry weather, and disappeared in cool, wet weather. Thus far the old theory of entomologists, that wet weather is detrimental to their increase appeared true.

But it is also true, that while in southern localities they were disappearing during a wet period, in central and northern Indiana and western New York they were rapidly gaining in numbers, under precisely similar conditions.

Turning now to Table H, we search for an element common to the invasions of 1861 and 1862 and 1889, bearing in mind that in southern Indiana the pest arose to the maximum during May and early June, and in New York during June and early July.

TABLE I.—*Comparative temperature and precipitation throughout the State of Indiana for March, April, May, and June,* 1889.

TEMPERATURE (DEGREES—FAHRENHEIT).

Counties.	Stations.	Number of years.	March. Normal.	March. Departure from the normal.	April. Normal.	April. Departure from the normal.	May. Normal.	May. Departure from the normal.	June. Normal.	June. Departure from the normal.
Southern		5	41.1	+2.8	54.8	—0.1	64.4	—1.9	72.2	—2.5
Dubois	Huntingburgh	6	41.4	+4.6	54.6	+2.1	64.0	—1.4	72.8	—1.0
Gibson	Princeton	5	41.8	+4.7	54.1	+1.1	64.7	—0.3	74.0	—3.3
Crawford	Marengo	6	42.3	+3.1	57.7	+1.1	65.3	—0.9	72.2	—0.3
Washington	Salem	6	41.3	+0.2	53.2	—0.1	64.2	—0.1	......	......
Switzerland	Vevay	21	42.8	+3.9	54.8	+1.3	65.4	—0.8	74.4	—3.5
Jennings	Butlerville	4	42.4	+2.9	55.5	—2.0	65.7	—4.0	73.7	—3.2
Greene	Worthington	6	39.6	+1.5	53.9	+0.9	63.9	—3.2	70.2	—2.4
Bartholomew	Columbus	6	38.4	+2.7	52.2	+0.2	63.4	—2.4	72.2	—3.7
Ripley	Sunman	6	39.4	+3.0	53.4	+0.4	65.3	—3.0	72.5	—4.3
Warrick	Dagonia Springs	6	43.4	+2.1	55.8	—0.7	64.6	—2.5	72.0	—2.3
Clark	Blue Lick	12	42.9	+3.1	55.3	+1.14	64.5	—1.4	74.3	—2.3
Central		5	36.7	+4.9	51.0	+0.3	61.9	—1.0	70.4	—2.6
Johnson	Franklin	6	37.9	+5.1	52.0	+1.4	63.0	—1.2	70.8	—2.5
Fayette	Connersville	7	37.8	+5.5	49.8	+3.0	62.6	—1.1	71.3	—3.6
Marion	Indianapolis	18	39.8	+2.8	52.5	+0.1	64.1	—3.9	72.5	—5.3
Rush	Mauzy	8	35.0	+6.1	49.2	+0.4	60.7	—1.2	68.7	—0.3
Henry	Spiceland	35	37.0	+6.0	50.0	+2.6	61.6	+0.7	70.5	—2.5
Wayne	Richmond	6	35.9	+2.0	50.5	—3.1	62.0	—4.1	69.5	—2.5
Randolph	Farmland	6	36.4	+6.0	48.7	+2.8	61.3	—0.3	69.7	—2.3
Delaware	Muncie	4	38.1	+5.2	52.3	—1.8	62.2	—1.1	70.0	—1.5
Northern		5	34.5	+3.8	49.9	—0.1	61.0	—2.4	70.0	—3.8
Tippecanoe	Lafayette	10	36.1	+1.7	54.7	—3.9	61.4	—2.1	70.0	—3.8
Carroll	Delphi	4	36.0	+1.7	51.6	—1.4	62.3	—2.7	......	......
Whitley	Columbia City	4	34.7	+1.9	48.9	—0.9	60.0	—2.7	69.5	—5.6
Steuben	Angola	5	31.7	+6.3	47.8	+1.4	63.1	—1.7	63.9	—0.4
State		7	37.4	+3.9	51.9	0.00	62.1	—1.4	70.9	—3.0

PRECIPITATION (INCHES).

Counties.	Stations.	Number of years.	March. Normal.	March. Departure from the normal.	April. Normal.	April. Departure from the normal.	May. Normal.	May. Departure from the normal.	June. Normal.	June. Departure from the normal.
Southern		5	2.67	—1.49	3.26	—2.45	3.94	+1.56	4.07	+0.65
Dubois	Huntingburgh	6	3.28	—2.48	2.98	—3.30	3.92	+2.63	3.86	—0.24
Gibson	Princeton	5	2.45	—0.45	2.43	—1.63	3.09	+1.31	3.55	+0.05
Crawford	Marengo	6	3.25	—2.15	5.28	—4.68	6.00	+3.85	5.27	+1.25
Washington	Salem	6	2.62	—1.56	3.68	—2.58	3.24	+2.05	......	......
Switzerland	Vevay	21	4.03	—3.20	3.40	—2.48	3.53	+2.64	5.07	—0.61
Jennings	Butlerville	4	3.35	—2.21	2.93	—1.72	5.56	+0.87	5.56	—1.85
Greene	Worthington	7	2.59	—0.58	3.04	—1.50	4.19	—1.29	4.51	+2.81
Bartholomew	Columbus	6	2.52	—1.65	2.60	—1.96	3.45	+1.35	3.50	+0.88
Ripley	Sunman	6	2.45	—1.22	3.41	—1.77	4.38	+1.48	4.35	+1.61
Warrick	Dagonia Springs	6	2.92	—1.11	2.88	—1.90	3.06	+1.02	5.10	—0.61
Clark	Blue Lick	12	2.73	—1.86	3.65	—2.70	4.09	+1.46	4.04	+0.18
Central		5	2.33	—0.98	2.82	—1.46	4.19	+1.43	3.80	+1.08
Johnson	Franklin	6	2.45	—1.10	2.68	—1.47	4.04	+0.33	3.80	+2.20
Fayette	Connersville	7	2.56	—1.70	2.32	—1.43	4.47	+2.12	4.37	—0.61
Marion	Indianapolis	18	3.85	—1.70	3.59	—1.47	4.15	+1.61	5.44	—0.76
Rush	Mauzy	9	3.50	—1.80	4.52	—2.44	4.89	+1.20	5.45	—0.75
Henry	Spiceland	35	3.90	—1.82	3.20	—1.52	3.35	+3.08	4.30	+0.40
Wayne	Richmond	6	2.38	—1.53	2.77	—1.95	4.21	+2.51	4.07	—0.33
Randolph	Farmland	6	2.18	—0.46	2.52	—1.45	4.42	—0.27	3.68	+1.91
Delaware	Muncie	4	......	......	......	......	......	......	......	......
Northern		5	2.02	—0.14	2.03	—1.15	4.46	+1.24	4.12	+0.61
Tippecanoe	Lafayette	10	2.39	—0.70	2.78	—1.91	4.80	+1.55	4.01	—0.77
Carroll	Delphi	4	1.92	—0.74	2.16	—1.35	5.82	+1.43	......	......
Whitley	Columbia City	4	2.01	+0.45	2.50	—1.45	5.17	+0.78	4.46	—0.67
Steuben	Angola	5	2.18	—0.18	2.21	—1.02	4.28	+0.97	4.48	—0.98
State		7	2.37	—0.86	2.70	—1.89	4.22	+1.28	4.16	+0.14

TABLE K.—*Records of rain-fall throughout Indiana during May, 1889.*

Place of observation.						Precipitation.				Number of days.			
Stations.	Counties.		Altitude above sea, in feet.	Latitude north.	Longitude west.	Total for month, including melted snow.	Greatest in 24 consecutive hours. Amount.	Greatest in 24 consecutive hours. Date.	Snow-fall.	Cloudless.	Partly cloudy.	Cloudy.	On which rain or snow fell.
Southern:				° ′	° ′				In.				
Mount Vernon	Posey	a b	410	37 58	87 54	4.53	3.35	29, 30	T	8	7	16	8
Huntingburgh	Dubois	a	....	38 21	86 59	6.55	3.55	29, 30	0	7	0	24	10
Princeton	Gibson	a	481	38 23	87 35	4.40	1.40	29, 30	0	14	13	4	7
Marengo	Crawford	a	....	38 24	86 24	9.85	5.70	29, 30	0	10	9	12	11
Salem	Washington	c	..	38 38	86 7	5.29	2.76	29, 30	0	14	8	9	10
Vevay	Switzerland	a b	525	38 47	84 59	6.17	2.60	29, 30	0	11	7	13	16
Butlerville	Jennings	a	..	39 3	85 33	6.43	4.02	29, 30	0	16	8	7	13
Worthington	Greene	c	540	39 9	87 0	2.90	1.86	29, 30	0	..	..	..	11
Seymour	Jackson	c	648	38 45	86 31	6.14	3.00	29	T	8	14	9	15
Columbus	Bartholomew	c	....	39 13	85 56	4.80	2.27	29, 30	0	9	10	12	12
Sunman	Ripley	c	1018	39 14	85 6	5.72	2.60	29, 30	0	14	8	9	11
Degonia Springs	Warrick	a	....	38 6	87 12	4.04	1.45	29, 30	0	15	5	11	10
Cannelton	Perry	c	....	37 57	86 42	4.53	1.96	29, 30	0	12	7	12	10
Blue Lick	Clark	a	1000	38 32	85 50	5.55	1.78	30	0	10	10	11	10
Jeffersonville	....do	a	....	......	......	5.78	3.43	29, 30	0	3	21	7	12
North Providence	....do	b c	575	38 25	85 54	4.78	3.27	29, 30	0	10	4	7	11
Mean	....	..	....	39 30	86 13	5.17	2.62	....	0	11	9	11	11
Central:													
Franklin	Johnson	a	....	39 40	85 3	4.37	1.88	29, 30	0	8	0	23	15
Connersville	Fayette	a	....	......	......	6.59	2.14	29, 30	0	12	4	15	12
Shelbyville	Shelby	...	....	......	......	4.65	2.15	29, 30	0	..	..	..	....
Indianapolis	Marion	a b	766	39 47	86 11	5.76	2.13	29, 30	0	6	9	16	15
Mauzy	Rush	b c	....	......	......	6.09	2.79	29, 30	0	..	..	..	14
Spiceland	Henry	a b	....	32 50	85 25	6.43	3.18	29, 30	0	6	20	5	13
Richmond	Wayne	c	969	39 51	84 53	6.75	2.68	29, 30	0	11	8	12	14
Rockville	Parke	c	722	39 46	87 10	5.75	2.60	29, 30	0	18	0	13	12
Farmland	Randolph	a	....	40 11	85 10	4.15	2.44	29, 30	0	8	9	14	7
Muncie	Delaware	a	....	40 11	85 25	.....	..	.....	0	20	0	11	8
Mean	....	...	....	.....	.....	5.62	2.41	.....	0	11	6	14	12
Northern:													
Lafayette	Tippecanoe	c b	661	40 27	86 55	6.41	1.92	29	0	11	6	14	12
Delphi	Carroll	c	580	40 36	86 41	7.25	3.87	29, 30	0	5	11	15	12
Marion	Grant	c	....	40 34	85 21	3.20	1.60	29, 30	0	..	..	..	7
Columbia City	Whitley	c	....	41 9	85 30	5.95	4.25	29, 30	0	..	..	..	7
Angola	Steuben	a	683	41 37	85 1	5.25	3.85	29, 30	0	10	5	16	7
Lagrange	Lagrange	a	980	41 37	85 26	......	....	.....	.....	..	..	..	....
Mean	....	...	....	......	......	5.70	2.91	.....	0	8	8	15	9

SUMMARY.

	Precipitation.				Number of days.			
	Total for month, including melted snow.	Greatest in 24 consecutive hours. Amount.	Greatest in 24 consecutive hours. Date.	Snow-fall.	Cloudless.	Partly cloudy.	Cloudy.	On which rain or snow fell.
				In.				
Northern counties	5.70	2.91	......	0	8	8	15	9
Central counties	5.62	2.44	......	0	11	6	14	12
Southern counties	5.17	2.62	......	0	11	9	11	11
State	5.50	2.66	......	0	10	8	13	11

The wet weather theory here appears broken, and a low temperature is the only element which appears uniformly through the months during which the Grain Aphis was, in all probability, increasing with the greatest rapidity. That cool weather should favor the development of these insects would, if true, be a new factor in the problem, not only of this, but other species also; and before leaning too heavily upon this evidence we should cast about for good reasons for this apparent ambiguity.

There is one very important element in this whole problem which we have so far left out of consideration, viz. natural enemies. While low temperature might not favor the development of the grain Aphis, or in fact, if the effect was slightly adverse, if the outcome was to destroy or retard the development of parasites, the ultimate result would be to favor the Aphis.

For myself, I can not get rid of the feeling that the indirect action of the weather of May and June—the action upon the parasites—was much greater than the direct effect upon the Aphis itself.

According to my field-notes, my earliest observation of the grain Aphis about La Fayette, lat. 40° 27′ N., during any year, was on April 27, and we have observed them during other years on grain early in May, in greater abundance than they were the present year on the 1st of June; yet in the former case no outbreak occurred. Up to the 1st of June, the Aphis was not exceedingly abundant on grain about La Fayette.

Even as late as the 7th their numbers on the heads of wheat were not so much greater than they had occasionally been in former years as to cause alarm; yet within ten days they were swarming in these same fields in myriads. This certainly bespeaks more of the effects of relief from the pressure of parasitism than from the effect of meterological conditions, especially a change from dry to wet weather.

The question may be asked, why, if this be true, were not the parasites destroyed in the southern portion of the State, late in May, thereby relieving the Grain Aphis from this check on their increase, and why the latter by reason of this relief did not, as the wheat became too advanced, overrun the oat-fields, as would have at that date naturally followed. The reply is that such results did follow to a limited extent, the oats being rather more seriously infested by the Aphis than farther northward, and the reason why this feature was not more marked was doubtless owing to the fact that the cold waves of the first and last of May, especially the latter, were less severe than farther north, and the effect on the parasites correspondingly less fatal.

The records of the State weather service show that the minimum temperature of the first four days of May at La Fayette was below the freezing point; and on the 22d, 23d, 30th, 31st, from 34° to 39° Fahr. The mean minimum for the entire State for the same month, according to the same authority, was, for the southern portion, 36° Fahr., for the central 32° Fahr., and for the northern 30° Fahr.

Buckton (British Aphides, vol. I, p. 70) has the following to say with regard to the effect of weather on this and other species of Aphides:

Violent changes of temperature seem much to check the multiplication of the Aphides. A cold rain, or the outburst of a thunder storm, will often cause the almost entire extermination of swarms, and wash them, never to return, from their native plants. Nevertheless, the close and hot atmosphere before a thunder storm seems to to be peculiarly suited to their propagation. At such times the winged forms occur in great numbers and take flight on the gentle winds, which transport them many miles to other feeding grounds, to become the foundresses of other colonies.

The effect of the parasites on the Grain Louse was simply astonishing, while their numbers were myriads. Going to the fields of recently harvested grain, if one stood in a position to bring the newly made shocks between himself and the setting sun, he could clearly observe the swarms of minute Hymenopters arising therefrom and flying away. Besides, the stubble-fields were overrun with lady beetles and their larvæ.

Nevertheless, there are good grounds for the belief that the heavy showers during the latter part of June and early July, in the central and northern portions of Indiana, washed many young from the heads of the grain and destroyed them. Besides, either the severe thunder and lightning which accompanied these storms or the rapidly maturing grain, or both, perhaps, caused the winged adults to betake themselves to the oat-fields, where they would probably have caused further damage had not their relentless foes, the Hymenopters, pursued them and continued their work of destruction.

It was a common sight early in July, in northern Indiana, to see adults of the grain-lice attached singly to heads of oats, sometimes with a few young clustered about them, assuming the form and color so indicative of parasitism. In southern Indiana, late in June, the same thing was observed on oats, and parasitized adults were also abundant on the heads of blue-grass, even long distances from grain fields.

In summing up the matter, it may be safely said that wet weather will not, of itself, prevent an outbreak of the grain Aphis, or dispel it after under full headway. It must be borne in mind, however, that cool wet weather, during May and June, will enable grain plants to sustain greater drafts on their vitality than will very dry and hot weather. It is also probably true that a cool temperature during spring and early summer is either directly or indirectly favorable to the development of the grain Aphis.

Regarding the life history of the species under consideration we have never found them in the fields at an earlier date than April 27. From this time we have an unbroken record of their occurrence up to July 9, when there is a break in their continuity of appearance until September 1, when full grown apterous females were found on leaves of early sown wheat. From this latter date we again have an unbroken record up to December 30. We have also observed the sexes pairing on November 11 and December 3.

We have several times attempted to follow the species through July and August, but have always failed. Adults placed on various kinds of grasses in breeding cages invariably died during July. The occurrence of great numbers of wingless parasitized females on heads of *Poa pratensis*, long distances from grain fields, strongly suggest this grass as one of its midsummer food plants. While in this and other cases we have been unable to rear Aphides on certain plants in breeding cages, yet we do not feel at all certain but that outside, under the usual environments, nature might accomplish precisely the same object. The results of breeding cage experiments with Aphides must always be accepted with extreme caution.

The present year we had young grain growing continually from spring to November, yet not a single grain Aphis was to be found on either this young grain or grasses from July 9 to late in October. Their limited numbers at this season may, however, be accounted for by the fact that they were very nearly exterminated in July by their natural enemies.

Dr. Cyrus Thomas states that in 1875, in Southern Illinois, he observed winged and wingless specimens on wheat during winter, and suggests that the species winters over in other forms than the egg.* There appears to be no good reason for doubting the truth of Dr. Thomas' suggestion, especially if applied to mild winters. During the time we have been located in a wheat-growing district the winters have been quite severe, so that we have not been able to follow the species through the cold months. The winter of 1888–'89 was a mild one, but we were absent in Australia during the entire time.

Siphonophora avenæ is by no means the only species of Aphides infesting the plants of our smaller cereal grains. An undescribed species of *Toxoptera* occurs on the leaves of wheat in the latitude of La Fayette, in June. We have carried this species through July and August on wheat in breeding cages, found it again in the fields in September, and from this on until the 22d of December. During the latter month they continued to reproduce in a room, which, though warm during the day, the temperature fell below the freezing point every night. I have not been able to follow the species through the winter months in the fields.

A species of *Aphis*, undistinguishable from *A. mali*, appears regularly every September, and, indeed, sometimes as early as July 17, on young wheat and rye. From the latter date up to the 12th of November they have been observed on young grain, giving birth to their young.

Notwithstanding the fact that the species is not distinguishable from the apple tree Aphis, yet the attempt to transfer them to the apple leaf, or vice versa, has invariably resulted in failures.

A second *Aphis*, as yet undescribed, is found about the roots of wheat, often in sufficient numbers to affect the plants. This species occurs throughout the entire State, from about the last of September, and

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*Eighth Rep. St. Ent. Ill., 1879, p. 53.

probably winters over in the fields, in other stages besides the egg, although we have never yet found them on grain during the early part of the year.

An undescribed species of *Rhopalosiphum* was found on spring grown volunteer wheat, on July 12, of the present year. A few days later adults, both winged and wingless, and young in all stages of development, were found on the heads of orchard grass, *Dactylis glomerata*, and also on the heads of spring sown rye, working precisely after the manner of the true Grain Aphis. This species I was not able to follow in the fields after about the 10th of August, when it left the heads of rye, and, though a large number were placed on young wheat plants, in a breeding cage, all seem to have died.

When this last species was confined on wheat, the same cage and plants were utilized as had been used in the attempt to carry the true grain *Aphis* through the months of July and August. But as none of the many individuals placed on the plants survived, a large number of heads of rye thickly infested by the *Rhopalosiphum* were placed in the cage. When the first winged adult appeared in this cage, I was not a little surprised to find it belonged to neither one of the species intentionally placed in the cage, but to a species of *Myzus*, which could have only gained admission by being introduced with one or the other or both of the other species.

By whatever way it gained admission, this *Myzus* has continued to throw off generation after generation, and at date of writing, November 25, is still reproducing, although during the entire time—nearly four months—it has had no other plants except wheat upon which to subsist. It is undescribed.

Still another species (a *Megoura* sp.?) was found giving birth to young, on leaves of young rye, August 9, but not observed afterwards.

The natural enemies of the Grain Aphis were, as we might expect, unusually numerous the present year, and especially those belonging to the *Hymenoptera*. Of these we had reared, during other years, a species of *Trioxys* in quite abundance, and this season the following occurred in great numbers: *Bassus sycophanta* Walsh, *Aphidius avenaphis* Fitch, *Isocratus vulgaris* Walker, *Encyrtus websteri* Howard, *Allotria tritici* Fitch, *Megaspilus niger* Howard, *Pachyneuron micans* Howard.

Of the Syrphids, *Sphaerophoria cylindrica*, *Xanthogramma emarginata*, and *Allograpta obliqua* were very numerous. A secondary parasite, *Bassus sycophanta*, was in some localities so exceedingly abundant that nearly all of these useful flies were destroyed.

Two species of Chrysopa were exceedingly useful. In a field of wheat, near Indianapolis, about the middle of June, these were so abundant that at every step, from one to four or five individual adults would be disturbed, and take wing. The field was but very slightly attacked by *Siphonophora*.

Of the Coleopterous enemies, the *Coccinellidæ* were by far the most industrious. Of this family probably *Coccinella 9-notata*, with its larvæ, was the most abundant and generally distributed species.

In a field of newly harvested grain, in La Grange County, within a radius of 3 feet from where I was standing at the time, fifteen individuals were counted, crawling about among the stubble. *Hippodamia parenthesis* followed next, in point of numbers, *H. convergens*, *H. 13-punctata* and *H. glacialis* being also found in quite large numbers in various localities. *Megilla maculata* was scarcely noticed at all, and *Anatis 15-punctata* but once.

Podabrus tomentosus was exceedingly useful in some portions of the State, while *Telephorus carolinus* was often quite numerous in the fields of the central part of the State.

ENTOMOLOGICAL NOTES FROM MISSOURI FOR THE SEASON OF 1889.

By MARY E. MURTFELDT, *Kirkwood, Mo.*

LETTER OF SUBMITTAL.

DEAR SIR: I inclose herewith such of my notes and observations on insects as may be of economic interest, and in this connection desire to express my sincere thanks for determinations and other assistance, for which I am indebted to yourself and to others of the official force of the Division.

Yours, very respectfully,

MARY E. MURTFELDT.

Prof. C. V. RILEY,
U. S. Entomologist.

GENERAL OBSERVATIONS.

The Cabbage Curculio (*Ceutorhynchus rapæ*).—A number of my correspondents in the central part of the State have informed me of the serious ravages of this insect in their hot-beds and vegetable gardens. Mr. F. M. Webster also wrote me, about the middle of May, that it had appeared in his garden in La Fayette, Ind. As yet I have not found it in Kirkwood or vicinity, and as it was with some difficulty that I obtained specimens for study, I have not been able to make such tests of insecticides upon it as would be practicable in the field. It promises to become a general and very considerable pest to the market gardener.

The Wavy-striped Flea-beetle (*Phyllotreta vittata*).—This insect appeared in great numbers this year in all parts of the State, being very destructive to peppergrass, early radishes, turnips, cabbage, and other *Cruciferæ* during the months of April and May. Mr. S. W. Gilbert, of Thayer, in the extreme southern part of the State, reported a loss of over fifty thousand cabbage-plants from the work of the larvæ on the roots. I could scarcely credit the statement that such extensive injury was attributable to this one insect until convinced by specimens of the pest, and of the injured plants which were excoriated and channeled on the surface of the roots from collar to tip, the foliage also being injured

by the mature beetles. A top-dressing of wood-ashes with a slight admixture of Paris green was recommended, but I was not informed with what results.

In company with this flea-beetle on the leaves of late radishes in our own garden, I was surprised to find great numbers of a species of *Podura*. I could not determine whether it produced any effect on the radish foliage independently, or why it should have appeared there so numerously.

Canker-worms (*Anisopteryx vernata*), except in orchards thoroughly plowed and harrowed the previous autumn, were quite abundant. Owing to the very warm winter, and consequent irregularity in emergence of the moths, cotton band traps, applied even as early as the first of March, did not capture as large a proportion of the females as usual. On some trees, therefore, the worms were numerous and where not killed by spraying were quite injurious.

The Plum Curculio, which last year caused scarcely any damage to the fruits usually affected by it, appeared this season with recruited ranks; and on peach and plum trees, where spraying was not practiced, or where the frequent rains washed off the arsenites, a large proportion of the fruit was stung. As confirmatory of the single broodedness of the species, I observed that all the very late peaches, whether free or cling stones, even when so severely punctured on the surface as to prevent the development of the fruit, were entirely free from worms, showing that the cuts had been made for food only.

Aphididæ.—It would seem as though all known and unknown species of this group of insects appeared in myriads throughout the Mississippi Valley, during the spring and summer. In many instances trees and shrubbery were killed outright by the punctures of their countless beaks, and the closing of the stomata of the leaves by their sticky exudations. So badly infested were the elms, maples, lindens, box-elders, and other shade trees, in and around Minneapolis, Minn., during the latter part of June that to pause or even pass beneath them was to endanger one's apparel from the honey dew that continually dripped from them, and from the black mold that soon covered trunk and branch and which "smutted" everything touching it. All other insects seemed to be repelled from the aphis-infested trees; not even a leaf-roller or leaf-miner could I see. In the September number of INSECT LIFE, mentioning the prevalence of *Aphis avenæ* in the grain-fields of many of the Middle and Western States, I observe that Missouri was omitted from the list. The insect, however, occurred quite extensively in the middle and northern portions of the State, but it appeared rather late, and but comparatively little damage was done so far as I have been able to learn.

Syrphus fly, Coccinellid and Chrysopa larvæ waged a fierce, but, at first, unequal warfare with the tiny hosts, assisted by *Aphelinus* and probably other smaller as well as larger allies, so that as the season

advanced the *Aphididæ* gradually disappeared and where seasonable rains followed the unfortunate plants measurably recovered, though the growth of trees and shrubbery was much retarded and distorted by them.

Codling Moth, not seriously destructive in the northern part of the State, but in the vicinity of St. Louis and in the southern counties, as I have been apprised by various correspondents, fully 50 per cent. of the fruit, on trees not sprayed, was destroyed by it.

The Stalk-borer (*Gortyna nitela*) committed its usual depredations in the leaf stalks of rhubarb and in shoots of blackberry and peach. Mr. S. W. Gilbert wrote me that it was so abundant in his young peach orchard that in the course of one walk among the trees he cut off twenty-five or thirty bored shoots. He says:

> The worm seems to enter at the second or third bud from the tip and bore through the heart as far as the body of the tree but does not enter the hard wood.

In the flower garden this insect has done considerable damage by boring the stalks of dahlias, cosmos, and other flowers.

The Flea-like Negro-bug (*Corimelæna pulicaria*).—Mr. E. S. Pollard, of Cameron, northwest Missouri, under date of May 22, sent specimens of this insect with the information that they were very abundant in his strawberry beds, and doing much damage by puncturing the bearing stems, causing the fruit to shrivel. As it was the fruiting season, I was at a loss to suggest a remedy, since this insect is not susceptible to the effects of pyrethrum, or other non-poisonous applications. In Kirkwood it appeared in great numbers on hollyhocks and various other flowering plants, for which the easiest remedy seemed to be to jar it into basins of soap-suds to which had been added a small quantity of kerosene.

Lygus lineatus appeared here and there on tufts of clover, about the middle of May, injuring the foliage to considerable extent. It inhabits the under surfaces of the leaves which it speckles with transparent dots and small patches which cause the leaves to curl and shrivel. Its broad, flat larva is of a dull, pale green color, variegated with a few ferruginous marks and shadings. The pupa is very similar, with the addition of the wing-pads.

The Tarnished Plant-bug (*Lygus pratensis* Linn.).—This insect was more abundant than usual throughout the State, and from numerous correspondents I received bitter complaints of its injuries to apple and pear buds and to strawberry beds. During the autumn it appeared in considerable numbers on chrysanthemums, on which its peculiarly poisonous punctures produce most disastrous effects. I was quite successful in driving it from our own plants by liberal applications of X. O. dust, which proved at the same time a good remedy for the brown aphis, which is such a common and unmanageable pest on these beautiful flowers. The plants were not injured in the least by the insecticides.

The Streaked Cottonwood beetle (*Plagiodera scripta*) appeared in our grounds during June on a young *Populus*, which it threatened to completely defoliate. The tree being small admitted of thorough drenching with a plant syringe with the solution of arsenic and ammonia—1 ounce of arsenic in 1 quart of aqua ammonia—1 tablespoonful of the solution to a gallon of water, by which means and a little hand-picking the pest was so thoroughly exterminated that it did not reappear later in the season.

The 12-spotted Diabrotica (*D. 12-punctata*) was a serious pest during the latter part of the season, not only on squash and cucumber vines, but on late sweet-corn, and especially in its injuries in the flower garden on the blossoms of roses, dahlias, and cosmos on which it literally swarmed. To save the flowers it was necessary to make the rounds two or three times a day and capture or put the beetles to flight. They were not much affected by any of the milder insecticides, and the arsenical remedies could not very conveniently be applied.

The European Cabbage-butterfly (*Pieris rapæ*) acquires one or more new food plants annually and threatens to become quite omnivorous. This year it proved in several localities very destructive to nasturtiums (*Tropæolum*) both in flower and vegetable gardens. None of its parasites have yet appeared, so far as I have been able to ascertain. It seems to have entirely supplanted our native *P. protodice* in this locality. Wishing to obtain some larvæ of the latter for a certain purpose, I made many examinations during the summer of the neighboring cabbage plantations, but did not succeed in finding a single one.

SPECIAL STUDIES.

I THE SPINACH BEETLE.

(*Disonycha collaris* Fabr.)

About the middle of April I observed the leaves of spinach in the garden were badly perforated, and, upon examination, I found on the under surfaces numbers of small, dingy, white larvæ, evidently of some Chrysomelid beetle. They reposed in the numerous depressions between the veins, and a slight shake or jar caused them to drop to the ground. The insects increased in size and numbers until by the middle of May all the leaves were badly injured and the gardeners hereabout complained that their spinach was so "worm eaten" this year that they could no longer offer it for sale. A few of the same larvæ were also found on young beet leaves, especially of the white and yellow varieties, and upon the wild *Chenopodium album*, the latter being, I suspect, the original food plant of the insect.

As the larvæ drop so quickly upon being disturbed, it is not often that they are observed by the gardener or cook, and the damage was attributed by many to "some kind of cut-worm." By plucking the

leaves, carefully, however, as many as fifteen or twenty "grubs" were sometimes found on a single leaf.

April 24 I collected a large number, which were placed in a jar in order that their development might be more closely watched. Most of these were still very small, only from 3 to 4^{mm} in length. When very young they merely gnaw the under surface of the leaf, noticeable on the upper side as small discolored spots, but as they increase in size they eat entirely through both cuticles, making large roundish perforations.

It is probable that there are but three larval molts, as, in the case of even the smallest larvæ under observation, I was able to note but two, and infer that one had been passed before they were brought in.

The larger larvæ entered the ground the 4th, 5th, and 6th of May, penetrating to a depth of only from one-fourth to one-half an inch and inclosing themselves in frail, nearly spherical, cocoons or cells of earth cemented with a viscid secretion. Larvæ, however, were found on the spinach throughout the month of May.

May 25 one of the beetles emerged, which proved to be *Disonycha collaris* Fabr.; and from this time until after the middle of June bred specimens continued to come out.

A package of specimens was sent to the Department in case it should be considered desirable to have drawings made of the different stages of development. Unfortunately this consignment did not reach Washington, and I did not learn of the failure until too late to replace it. Specimens were, however, preserved in alcohol, which retain all the important characters.

No account of the immature stages of the insect or of its spinach-feeding propensity is to be found in any work on economic entomology to which I have access, and I think it has not heretofore been recognized among the pests of the vegetable garden. I therefore subjoin the following descriptions.

Egg, not observed.

Mature larva, from which the young differ only in size, 9^{mm} in length, 3 to 4^{mm} in diameter; form subcylindrical, tapering slightly each way from middle segments, which, both in resting and crawling, appears somewhat elevated or "hunched up." Color a dirty, rather livid white, with a shiny, slightly viscid surface, each segment produced with ten conical papillæ—lateral ones largest—each of which terminates in a minute bristle. Head about one-half the diameter of the thoracic segments, oblique, circular, corneous, fulvous, paler in front, with dark brown mouthparts and two dark brown, somewhat elevated, spots on each side. The posterior end of the body terminates in a dark brown, corneous wing, most pronounced on the dorsal side, fringed with bristles. This is always appressed to the leaf, and in moving the bristles assist in propulsion. Legs concolorous with general surface, but with fulvous or dingy brown annulations, the terminal joint being entirely of the dark color.

Pupa, 8^{mm} in length, 3 in diameter across dorsum, with elytra and wings partly extended as in other pupæ of *Halticinæ;* the legs drawn up and folded close against the body. Color pearly white in all its parts, acquiring a translucent gray tinge before the last transformation.

Beetle quite pale at first, gradually acquiring the dark metallic green of the elytra, buff thorax, dark legs and under surface and other colorational characteristics of the mature insect.

This species seems to be but single brooded, as no young larvæ were to be found after the first of June. As, however, the spinach beds were rooted out before midsummer in all the gardens of the vicinity, I can not be quite certain upon this point, but could not discover it on beets or any of the native *Chenopodiaceæ*. The insect is one to which it is difficult to apply insecticides, as the leaves which it attacks lie close to the earth and it is, as a rule, on the under side.

New Rose Slug.

(*Cladius isomera* Harris.)

Early in August a friend, residing at St. Charles, Mo., sent me specimens of a Tenthrediuid larva that was working on her rose bushes, especially on climbers. This species, new to me, devours the entire substance of the leaves, gnawing into them large ragged holes and webbing them together in the formation of its cocoons, greatly injuring and disfiguring the plants. It is characterized as follows:

Mature larva 12^{mm} in length, 3^{mm} in diameter across thorax, from whence it tapers very slightly backward; form cylindrical. Color, pale bluish-green, surface clothed with tufts of soft gray hairs. Head opaque, dull whitish green, under the lens densely mottled with pale, ferruginous, small black dot, above which is a rectangular ferruginous spot on each side. Twenty legs, concolorous with general surface. Spins up between folded leaf or between two leaves, in glassy, gummy, pale brown cocoon, 7^{mm} long, of an oblong shape, flattened on both sides against the inclosing leaves and with many gummy threads spreading in every direction.

Cocoons were formed in rearing cage August 20. Flies appeared August 29. On the 2d of September I detected two in the act of ovipositing, with their well-developed "saws" deeply buried, one in the midrib, the other in the petiole of a fresh leaf. Two or three minutes were occupied in the placing of an egg and each fly put in three or four without pausing to rest. By carefully detaching the surrounding fibers the egg was revealed. It is oblong, scarcely 1^{mm} in length, and almost transparent. These eggs failed to hatch, probably for lack of fecundation.

From what I have learned from my friend, and infer from the habits of the insect in the rearing cage, there are an indefinite number of broods during the summer, and where it has become established it is therefore a more serious pest of the "queen of flowers" than even *Selandria rosæ*. I do not doubt, however, that by killing off the earliest broods with drenchings of an infusion of white hellebore, it could be kept in check and by perseverance in the treatment eventually exterminated. I have not been informed of its occurrence in any other part of the State.

The White Fringe Slug.

(*Selandria* ? sp.)

The White Fringe tree (*Chionanthus virginica*), in its season one of the most exquisite of flowering shrubs or small trees, is subject to the annual attack of a medium-sized, spiny slug that perforates the leaves with small round holes after reducing the greater number of them to mere lace-work. This species is single brooded, but the parent flies appear irregularly and larvæ may often be found from the latter part of April until the end of May, in the interval seriously disfiguring, often killing, the foliage. It lives on the under side of the leaves and feeds chiefly at night. Full grown larvæ from 9 to 12^{mm} long, 3^{mm} in diameter across the thoracic segments, form cylindrical, nearly equal throughout, or tapering slightly backward from thorax. Color greenish-white, surface very rugose, dorsum and sides quite thickly beset with bifid spines, those on dorsum jet black, arising from velvety black spots and being largest in the subdorsal region; lateral spines pale. Head about one-half the diameter of thorax, almost spherical, jet black, immaculate. Legs, 22 in number, concolorous with general surface, and unusually well developed. With me it has proved a difficult species to rear, and I confined the larvæ for several successive seasons without getting a single fly, and last spring but two from a large number of larvæ developed. In the rearing cage, after ceasing to feed, the larvæ desert the leaves and wander restlessly around the cage, many of them dying without entering the ground. The few that transform inclose themselves in very brittle, nearly spherical cells about an inch below the surface, and as with most other saw-fly larvæ that enter the ground brook no disturbance during the quiescent period. The two flies that I succeeded in rearing came out about the middle of April.

Syringing the under sides of the leaves with a strong infusion of white hellebore, or with Paris green in liquid suspension, will kill the pests, with but little detriment to the foliage.

DESCRIPTION OF THE LARVA AND PUPA OF PALTHIS ANGULALIS.

Among the insects trapped last spring in loose cotton around the trunks of apple trees were a considerable number of a dingy-colored noctuid larva, about 1 centimeter in length by 4^{mm} in diameter, of nearly equal width throughout, the segments appearing somewhat hunched together. Surface rough, of an earthy-brown color, palest on dorsum. Under the lens, especially after being dropped in alcohol, a tinge of green appears, and the paler cast of the dorsal surface is resolved into a spreading V composed of minute white stippling. This is especially pronounced on the posterior segments, where the angle of the V is developed into a papillate elevation. Head small, much retracted, dark brown; legs and prolegs, and also to some extent the entire ventral surface, verdigris green. These larvæ were found from the 1st to the 5th

of April, and, when placed in the cage with opening apple buds, nibbled a little, but almost immediately changed to pupæ within a cluster of webbed leaves. Pupa smooth, dark brown, without any especially distinguishing characters. Three imagines appeared April 24. They were of a species which had been long before determined for me as a *Palthis angulalis.*

With the idea that possibly the immature stages of this insect had not previously been observed, I submit the above descriptions.

INSECTICIDES.

White arsenic in ammoniacal solution—1 ounce arsenic to 1 quart aqua ammonia—one tablespoonful of this to a gallon of water proved a failure in the case of most insects, while it still scorched the leaves somewhat.

A soda solution made on a smaller scale had much the same effect on the foliage of peach and plum trees, and was not, so far as could be observed, efficient in protecting the fruit from curculio.

White arsenic in boiling water, the latter being only a partial solvent, in the proportion of an ounce of arsenic to 20 gallons of water, was sprayed upon young peach and plum trees without injury to the foliage. The frequent rains of the late spring and early summer rendered many of the applications futile in the case of the curculio and codling moth. Paris green in liquid, 1 pound to 100 gallons of water, has been found the safest and most reliable insecticide for use against the canker-worm and codling moth. Its effects on insect life seem to be due not alone to the percentage of arsenic, but to the general combination, while on vegetation it produces less injury than London purple or any of the solutions of pure arsenic.

In my somewhat limited experience the petroleum emulsions can not be excelled as a remedy for all species of scale insects, and when applied according to instructions, do no appreciable injury to trees and shrubs.

X. O. Dust.—Late in May I received from the Department a package of this new patented insecticide, with instructions to test its value on various injurious insects. It is to be applied full strength and claims to kill by contact and at the same time to be innoxious to man and the higher animals and to vegetable life.

June 1.—Applied the powder about 9 o'clock in the morning to *Doryphora* larvæ on potato, to late specimens of the rose-slug (*Selandria rosæ*), to *Aphis persicæ* on young peach and plum trees, and to Aphis sp.? on chrysanthemums; also to young cabbages and radishes, on which flea beetles (*Phyllotreta vittata* and *zimmermanni*) were abundant and destructive. Three hours later visited these plants and noted following results: Rose-slugs considerably affected, showing symptoms of sickness and paralysis and dropping from the leaves when jarred. *Doryphora* larvæ not seriously affected, only the smaller ones had dropped, while some of those nearly grown continued feeding, appar-

ently not inconvenienced by the dust that adhered to them. Flea beetles not killed, but evidently demoralized and deserting rapidly. Its effects on *Aphididæ* were quite satisfactory. All species to which it had been applied seemed to be killed or paralyzed and had withdrawn their beaks from the stems or leaves, and if they had not already fallen did so upon the slightest jar. At the same time *Chrysopa* and *Coccinellid* larvæ appeared but little, if any, injured, and were seen making their way to other hunting grounds on which the game should not be so pungently spiced. Syrphus-fly larvæ, however, did not escape, and all that received much of the dust were killed.

At 7 in the evening more of the powder was distributed on infested potatoes and on all species of Aphis that could be reached.

June 3.—The effects of the Dust on the Colorado potato-beetle are by no means so immediate and thorough as claimed in the circulars of the manufacturers. Repeated applications would seem to be necessary to kill the larvæ, while according to my experience the perfect beetle will live for days thoroughly dusted with the powder and inclosed in a box. At the same time it certainly does protect the plants to which it is applied, especially while fresh, by acting as a repellant.

September 10.—Tested the Dust on larvæ of the cabbage butterfly which are beginning to be found again in cabbage fields. Used the insecticide in the open air, also on a few full-grown larvæ placed in jar, under muslin cover.

September 15.—Plants dusted seem almost entirely free from worms, but several of the larvæ confined completed their first transformation without apparently receiving any injury from the powder.

September 21.—Repeated these tests with powder taken from the bottom of the can and found that young *Pieris* larvæ succumbed to its effects in two or three hours, while the larger larvæ often lived more than twenty-four hours, not eating, however, in the mean time, but lingering in a lethargic state until dead.

October 19.—Renewed these experiments on the latest brood of worms which are now to be found of all sizes on cabbages, turnips, and nasturtiums. The immediate effect of the powder is to cause the larvæ to cease feeding and toss themselves about uneasily, making efforts to free themselves from the irritating substance. Two hours later all were in a lethargic state, many lying upon their sides in the folds of the leaves and on the ground. They would squirm when touched, but gave no other sign of life. Twenty-four hours later all the small larvæ were dead; the others that had passed the second molt still lived, but were inactive with a sickly color. Forty-eight hours afterward all were dead. From these tests and experiments I conclude that this X. O. Dust may be classed with reliable remedies for this and probably other Lepidopterous cabbage pests, its value being nearly equal to that of Pyrethrum powder.

This remedy was also used on Tarnished Plant-bug with the effect of

driving it from the dusted plants, although bugs confined in a box with it would survive several days.

The little *Halticus pallicornis*, which was this year very troublesome, not only in the clover fields and vegetable gardens, on beans, cucumbers, etc., but was especially destructive to asters, was also routed by having this powder puffed on the under side of the leaves; the young bugs were killed and the mature ones driven away.

The Dust was further tested on a few late cut-worms, *Agrotis saucia*, *Celæna renigera*, and some other species which I can not name, but without much effect, as the powdered worms in the course of an hour all crawled out of the deep box in which they had been confined and escaped.

All hairy larvæ, as in the case of Pyrethrum, seemed insensible to its effects, so also did the striped and twelve-spotted cucumber beetles and other mature Coleoptera and the squash-bug.

There are quite a number of injurious insects on which I did not have opportunity to use it, and on which I hope to experiment with it another season.

From my experience with it this season I should rank it among the second-class insecticides, producing similar effects, but not quite equal to the California Buhach, but still valuable for use against certain insects on which it is not safe or expedient to employ the arsenates.

NOTES ON PHYLLOXERA RILEYI FOR 1889.

June 15.—Received instructions through Mr. Howard to collect and prepare specimens of *Ph. rileyi* in all its stages in fluid and in balsam on microscopic slides.

The post-oaks (*Q. obtusiloba*), on which the insect chiefly occurs on the place, were found to be less abundantly infested than during other years. The first leaves which have attained their growth and are beginning to toughen are, however, considerably speckled with their punctures, especially along the midrib and principal veins. Very few besides the pale yellow, smooth, elongate forms are noticeable.

Put up a number of infested leaves in alcohol reduced about 60 per cent. with water. (These I afterwards learned from Mr. Howard did not keep, the alcohol being perhaps too strong). I also prepared slides.

July 22.—Have just returned from Minnesota. Sent slides on to Washington. Examined leaves of post-oak around home, but found no winged *Phylloxera*, and very little change in the specimens on the leaves during the last month.

Among other insects preying on the aphis is *Œcanthus latipennis* in noticeable numbers, one or more on the under side of nearly every leaf. They are now nearly full-grown larvæ. The puzzle is how they come to be on the oaks, when I have never found their punctures in the twigs and when some of the trees are at quite a distance from raspberry or grape vines, in which they mostly deposit their eggs.

July 29.—After driving about the country in several directions I

found on the roadside about a mile from town some post-oak sprouts on which *Phylloxera* abounded in all stages of development. The pale smooth variety was most numerous on the older and tougher leaves, while the darker, tubercled larvæ and pseudo-pupæ and a few winged specimens crowded the unfolding second growth. The young leaves were much curled and distorted by their innumerable punctures. The aphids were preyed upon by the larvæ of the green *Chrysopa* and of one or two small Coccinellids; the deep red larvæ of a small Thrips was especially active and numerous among them, as also was the whitish gray larva of a small bug (No. 3 of my consignment of October 2).

Put up specimens on slides and sent some alive to Mr. Howard in tubes; also some in alcohol. I also placed winged individuals in three different sizes of tubes and on clean leaves in water in a glass jar.

August 3.—Notwithstanding all my care all the winged lice perished without leaving any eggs, to my great disappointment. Probably the extreme heat of the weather was unfavorable. Cleaned and disinfected my tubes and put in fresh winged forms and closed the tubes with loose cotton instead of cork to prevent excess of moisture.

August 3.—Another failure. All the specimens dead and molded and no eggs. I can not understand it.

August 15.—Made another excursion out into the country and succeeded in obtaining a very few. Nearly all the young oaks so badly infested two weeks ago are entirely cleared, probably by the migration of the winged forms and the destruction of eggs and wingless forms by predatory insects. The tender shoots are also killed and stand up stiff and dry; the drought being severe, there was no opportunity for them to recover from the attacks of the aphis.

On the lower mature leaves the insect still abounds in its wingless forms, mostly the flat, pale, smooth variety. Put seven of the winged aphis into a very small tube with a bit of mature oak-leaf and closed it tightly with common cork. (The rubber corks kill all insects inclosed with them very shortly, probably with their sulphurous emanations.) Also put about a half dozen on growing sprouts of oak, out of doors, but which seemed to be entirely free from infection, inclosed under fine muslin cover.

August 17.—Have at last succeeded in getting nine eggs in the small tube. These eggs do not differ much from those of the ordinary apterous form. On close comparison they seem rather more opaque and of a deeper yellow tint than the latter, but even in these particulars there is some variation. Each individual produces from one to three eggs; and usually perishes beside them.

August 21.—Eggs still healthy and beginning to show segmentation with two red eye-spots on the cephalic end. There is evidently a slipping backward of the thin pellicle that incloses them, although as yet no motion is discoverable. The eggs were all laid on the glass and not on the portion of the leaf inclosed with them.

August 22.—Three *Phylloxera* have hatched from the eggs and one

has crawled quite a distance. The egg-shells or pellicles are left as an almost transparent round dot at the place of hatching. Nearly all the substance of the egg seems to be absorbed into the young aphis. Inserted a bit of fresh young leaf, but they do not seem to be attracted to it, and remain crawling on the glass.

August 23.—Two more have hatched. They appear all alike so far as can be ascertained with a lens. Three were sacrificed for microscopic examination. Have the specimens under almost constant observation, but am not able to find them pairing or exhibiting any sexual attraction. Neither can I induce them to feed on even the tenderest bits of leaf. They appear precisely like the parthenogenetic forms through my lens, which is not sufficiently powerful to resolve the mouth parts and genitalia.

September 1.—Only two still alive and no eggs. Transferred the survivors as carefully as possible to fresh leaf and placed in clean tube.

Examined inclosed leaves out of doors but could detect neither eggs nor larvæ. It is an almost impossible task to keep track of such microscopic creatures in the open air.

The wingless lice have now become quite abundant on all our post-oaks. I do not find them on the white oak proper, but as I have examined them almost daily since the middle of July I am confident that none of the winged individuals occurred on any of the oaks on the place. I believe they never do occur in any numbers except on the more succulent growth of sprouts where living trees have been cut.

September 10.—All my progeny of winged lice have perished without leaving a single egg. Made another excursion into the country but obtained only two or three winged individuals which I put in tube, but of which I do not entertain much hope.

On one of the leaves out of doors, isolated about a month ago, I find by critical examination a very few minute specimens which are probably the progeny of the winged forms inclosed. Put some in balsam, though I can not see that they differ from the other wingless young on exposed leaves.

September 15.—No success with the last inclosure in tube.

October 25.—Have had one or two quite hard frosts. Leaves all turned in color, and *Phylloxera* becoming very active, congregating along principal veins and migrating on to the twigs. Their insect enemies have mostly disappeared and I notice that eggs are more plentiful than usual on the leaves.

From my observations this year I incline to the opinion that the winged form is necessary merely for the spread of the species, and that the young from the eggs of this form are not necessarily true-sexed individuals, although it is possible that these may occur without any especial regularity from the eggs of both winged and wingless forms.

Another year, if nothing happens to prevent, I will try to have some oaks in flower pots for more convenient and natural colonization of the *Phylloxera*, and for greater ease in examination.

REPORT ON CALIFORNIA INSECTS.

By ALBERT KOEBELE, *Special Agent.*

LETTER OF TRANSMITTAL.

ALAMEDA, CAL. *October* 25, 1889.

SIR: I herewith submit my report upon observations made and work done since my return from Australia.

After returning to Alameda on April 15, some time was taken up in writing out my reports upon work done in Australia, and also in assisting in raising and distributing in the northern part of this State the Australian Ladybird-enemy of the Icerya. This Ladybird does remarkably good and speedy work everywhere. As usual my chief work has been the breeding and studying of all insects, injurious and otherwise, that have come under my notice, the special notes on which will accompany material that will be sent in.

Respectfully,

ALBERT KOEBELE.

Prof. C. V. RILEY,
U. S. Entomologist.

THE MADRONA TREE BORER.

(*Polycaon confertus* Lec.)

This destructive beetle occurs to a greater or less extent every spring and summer upon various fruit-trees, vines, etc., boring into the fresh wood and destroying it. During my stay in the Santa Cruz Mountains the past summer they were observed everywhere, and most abundantly during May and June. On any dead tree, as soon as the leaves begin to fade, this beetle may be found, though always most abundantly upon the Madrona tree (*Arbutus menziesii*). Old trees of this species, such as have been allowed to lay on the ground for a year or two, are always completely perforated with holes from which these beetles have made their exit. In cutting through, one finds the wood nothing but mines produced by the larvæ, the mines generally running lengthwise, but often crossing each other. The Madrona tree seems to be the ordinary if not the only plant in which the beetle breeds. Notwithstanding that the mature insect bores in almost any kind of fresh wood, and especially favors such as has been somewhat injured by the hot sun, the larva is

not, or has never yet been, found in such places. It is the general belief here that it breeds in the wood of Oak, yet, so far as my experience goes, its larvæ are never found in other than the Madrona wood. It is very remarkable, in view of the above, that they should live and transform within apples from which this beetle has been bred.

On August 2, 1887, at St. Helena, Cal., a large number of the nearly grown apples upon trees in a private garden were observed to be dead and yellowish brown. One of these, taken to Alameda and examined, proved to contain a small whitish Coleopterous larva. This was living and thriving on the dead and dry apple until April 16, 1888, when it transformed to a pupa, from which the mature beetle issued on April 28. Since then no infested apples have been observed, nor have I seen any of the large fruit in the condition described above. The work of these beetles was witnessed in the Santa Cruz Mountains May 25, 1888, chiefly upon grapes and plums, yet they will attack olives and other trees as well. In many cases the shoots of grapes are cut off entirely and fall to the ground, where either one or both sexes may be found at work. In one case I noticed a plum tree the northern branches of which were entirely destroyed. The beetle will often make several holes into the center of a branch before entering; no doubt being compelled to leave on account of the copious flow of sap. Seven such holes were found in one branch, in the lowermost of which the beetle had entered and formed a tunnel of about 3 inches in length. On the other branches, aside from the many holes started, but two tunnels were found and no insects were present. This will show that one of these beetles alone is capable of disfiguring an entire tree, while two or three specimens can destroy a tree.

As a remedy, the recommendation of clearing and burning the dead Madrona wood alone would certainly have a most remarkable effect in reducing the numbers of this beetle.

(*Chrysobothris mali* Horn.)

The larva of this Buprestid is very destructive to currant bushes. It is found in the Santa Cruz Mountains, at least in such numbers as to destroy all the plants. Indeed, it is impossible to raise this fruit in that district on account of this insect. They have not been observed as yet in the valleys, where in their place *Ægeria tipuliformis* Linn. is more numerously represented upon this plant than in the hills. As many as fifteen or even twenty Buprestid larvæ may be found within a single plant, the stems of which naturally die and break off near the ground. The beetle is found most abundantly during June and July, when they can be seen resting on the plants generally near the ground during sunshine. It is then that they lay their eggs on the lower part of the branches and close to the ground where most of the larvæ are found. Eggs are also placed at a height of 2 feet, or even more, according to the size of the plant, and below the ground to the depth of

several inches. Where the larvæ are very numerous the plants will die before the larvæ are grown, and most of the latter will perish; only such as are situated near or below the ground will survive. Empty pupæ of two species of parasites were observed within the burrows of the larvæ, both apparently belonging to the Ichneumonidæ.

As a remedy, the collecting of the beetles may be recommended. During early morning and evening they may be found either on the currant bushes or the surrounding trees, almost always at rest on and within dry and dead leaves from which they can be shaken into an umbrella. During their operations upon the plants in the day-time it is difficult to get near them as they are very quick on the wing and exceedingly shy. Collecting and burning the infested plants during winter, and also the whitewashing of lower parts of plants may have a good effect; this should be done about the end of May.

(*Diabrotica soror* Lec.)

This beetle occurs occasionally in such numbers as to become exceedingly destructive to fruits and vegetables. As yet the earlier stages have not been studied. All attempts to get eggs and larvæ have so far been a failure on my part as well as on the part of other entomologists. A large number of the beetles were kept in confinement for weeks with various living plants without any results. The larva, without doubt, will be found to have the same habits as the other species of the the group,—feeding upon roots of various plants. Fortunately this insect is preyed upon by a dipterous larva, which without doubt destroys the greater number of them, in certain years at least. As early as 1886, while at Los Angeles, Mr. Alexander Craw, of that city, showed both Mr. Coquillett and myself the larva infesting this beetle. I did not succeed in breeding the same until June last, and Mr. Coquillett reports recently of his partial success in this particular.*

THE TENT-CATERPILLARS.

(*Clisiocampa* spp.)

From year to year these worms become more and more numerous upon fruit trees. Mr. Stretch in his paper on the genus† cites six species as occurring on this coast,—*C. californica* Packard, as feeding upon *Quercus agrifolia; C. fragilis*, Stretch, from Nevada; *C. constricta*, Stretch, on *Quercus conomensis; C. strigosa*, Stretch, from Yosemite Valley; *C. erosa*, Stretch, from Oregon; and *C. thoracica*, Stretch, as feeding upon Willow. The genus, however, seems to be far more numerously represented. In addition to this I have bred one species from the Sierra Nevada Mountains upon *Ceanothus* and wild cherry (*Prunus demissa*); a second species was found to be very abundant in Los An-

* Insect Life, Vol. II, No. 3, p. 74.
† Papilio, Vol. I, No. 5, pp. 63-69.

geles County upon a species of Oak; a third species was bred in the Santa Cruz Mountains feeding originally upon *Ceanothus thyrsiflorus*, but it was extremely abundant also upon fruit-trees, especially prunes and plums. I also found eggs of one of these moths in Shasta Valley upon a species of wild Currant. Of all the species the most abundant upon fruit-trees was *C. thoracica*, originally feeding upon Willow. This species defoliated most of the trees in Napa and Sonoma Counties last year. On my visit to Sonoma County this month (October), I found numerous old skins still present everywhere upon apple trees. They were either *C. thoracica* or *C. constricta*,—these two larvæ resembling each other somewhat. Fortunately the eggs as well as the larvæ are preyed upon by numerous parasites. Professor Rivers, of Berkeley, informed me that of one egg-mass of *C. constricta* each egg produced a small hymenopterous parasite. I have myself bred something similar from egg-masses on *Ceanothus cordulatus*. The old remedy* will be found best, viz, cut off and burn the egg-clusters during the winter, and collect and burn the nests in spring.

CUT WORMS.

Various Noctuid larvæ are usually numerous and destructive to orchards, vineyards, grain, and vegetables during spring, attacking the young foliage, twigs, and even fruit of trees, while in vineyards they often defoliate large numbers of the vines. As yet I have never been able to obtain any specimens of these larvæ from the injured field for breeding. Dr. Behr, of San Francisco, has shown me one larva that had been received from Santa Cruz, where they injure the vines; he did not, however, succeed in breeding them and the species is as yet not known. The larvæ bore the closest resemblance to those of *Agrotis messoria* Harris (*cochranii* Riley),† yet many of these Agrotid larvæ resemble each other so closely that their distinction can not be made with any certainty. A similar insect, if not the same, was bred from the eggs. (No. 378k). During September and the first of October, 1887, many of these moths came to sugar at Alameda, and were at the time the most common of all so collected. A number of them were confined in boxes but no eggs could be obtained until the middle of October. The eggs were of a straw-yellow color at first and after ten days changed to a dark grayish color, showing that the embryo had come to maturity. The young larvæ, however, did not come out before the rains set in, December 8, at which date they began to issue and continued to appear into January, 1888. They were kept and fed in a room and attained full growth in about five weeks, pupating at the end of March and issuing as moths one month later. This peculiarity of hibernating either in egg, larva, or pupa state during the dry season has been observed in numerous other insects in California, which are

*Professor Riley's Third Missouri Report, p. 120. † *Ibid*, pp. 74-76.

dependent upon such plants as are dried up from July until the rains set in, generally October or November. I will give here the history of one of these:

Agrotis crenulata, Smith.—On September 29, 1887, one pair of these moths was found about 10 p. m. *in coitu* on the upper side of a leaf of *Quercus agrifolia* at Alameda. The female began to lay her eggs the following day and continued until October 10, after which she died. On counting it was found that the number of eggs was 1,026. The young larvæ began to issue on October 12. They are, when full grown, very similar to those of *A. clandestina*,* for which they were taken before being bred. Naturally all such larvæ grow very slowly during the winter months, and reach their full growth about March, when they may be found most anywhere amongst grass, grain, or vegetables. Their chief food, however, consists of grasses. From larvæ that entered the ground in breeding cages on March 12, the first moth came out on April 16. In a state of nature it would be about the same probably, allowing for a week's variation either way in the appearance of the moths according to the situation of the chrysalids. The moths are found from April to July, being most abundant during May and June, at least in localities where food is sufficient. In the Santa Cruz Mountains they were observed to appear soon after dark upon the flowers of *Æsculus californicus* (Buckeye), and could be seen in numbers every night until the flowers disappeared; in other localities, where flowers and natural food are not so abundant, they may retire sooner into their hibernating quarters. During June, 1886, I found them very abundant in a deep, shady cañon in Los Angeles County, amongst leaves, flying up at my approach and settling down a short distance off. On my visit to the same locality one month later not one moth was seen on the wing. But if at this time one searches closer down amongst the dead and damp leaves they will be found in a semi-dormant state. After being exposed a short time they soon fly off to a dark corner and disappear again. In such condition they were observed all last summer in the Santa Cruz Mountains. In open country, distant from woods, they may occasionally be found hidden under or between boards or in old stumps, rubbish, etc. They prefer, however, to hide in the woods amid the dead leaves found there. As in other parts the warm rays of the sun in the spring awaken many of the hibernating insects, so here the first rains in fall will do the same, especially with the Noctuidæ.

NOTES ON THE HABITS OF THE CODLING MOTH AND ITS ENEMIES AND PARASITES IN CALIFORNIA.

During my repeated visits to the Santa Cruz Mountains the past summer some observations were made upon the Codling Moth and its enemies which may be of interest. The moth as a rule is double-brooded in that locality, and no doubt will not differ in its habits to any extent

* Professor Riley's First Missouri Report, p. 79.

throughout California. They may appear somewhat earlier in the valleys. From dates noted in 1887 some of the moths were out on April 22 at Santa Clara, and one larva found then did not produce the moth until May 10. Two days after this they were also observed flying at Alameda. One larva found under bark of pear tree at Los Angeles on July 19, 1886, and evidently of the first brood, did not produce the moth until the end of April the following year. During August, 1887, the moths were abundant at Alameda; on the 2d of the month a cocoon was found about 8 feet from the trunk of the tree, under a fallen apple, from which the larva had issued. The moth from this appeared on the 13th of the same month. Two days later, on a hot and sunny day, while walking through an old apple orchard at 10 p. m., moths started up either from the trunk or lower leaves of nearly every tree and settled down again, generally higher up and on the upper side of leaves exposed to the sun.

Larvæ and chrysalids were found in abundance the same day, and from one of the latter a parasite issued on August 26. This proved to be *Pimpla annulipes*. Up to September 17 moths issued from the chrysalids; one larva that pupated during this month did not, however, produce the moth until December 10. During 1888 the first moth was observed at Alameda as early as March 17, sitting on the upper side of an orange leaf exposed to the sun. But very few of the apple trees were in bloom at this time. Two days later moths began to issue in the house from larvæ collected the previous December. Several issued up to March 28. The present season the moths were not observed in any numbers before May 25 in the Santa Cruz Mountains. The fruit at this time was about 1 inch in diameter. From this date on until the end of June there could be seen at dusk from 25 to 50 on each tree. The place is situated on the east side of the hills. About a half hour after the sun disappeared behind the mountains, and while it was yet visible for nearly that length of time on the opposite hills, the moths began to appear, flying with quick movements around the trees, chiefly near the top, and settling down again upon the leaves or fruit from time to time. This was kept up until towards dark when they became less numerous. During this time both sexes may be readily collected with a long butterfly-net. I have taken many near the ground on the lower leaves and often distant from fruit trees. By their peculiar flight they are easily distinguished from any other species of moths.

About the middle of August, at which time some of the fruit had already been taken off, the second brood made its appearance, yet at this time many larvæ could still be found within the infested fruit, and from material collected then and taken to Alameda, moths came out in numbers until September 12. I was informed that Bartlett pears taken from the trees when the second brood had made its appearance were all sound, not one in twenty being wormy. On examination, however, I found the opposite to be the case. About one pear in twenty only was

found without any eggs or traces of young larvæ of Carpocapsa, the second brood having already begun its destructive work. From these few notes it is evident that with a little care early fruit can be kept almost free from the attacks of the worms, while with later sorts this becomes more difficult, and such fruit generally is rendered useless by the attacks of the second brood, and is fed to pigs.

Enemies.—Enemies of the Codling Moth appear to be quite abundant in California already. I have indeed been surprised in finding minute Chalcids infesting the eggs.* These are not numerous, and had not been observed on eggs of the first brood, yet they may have been present. In fourteen boxes of Bartlett pears examined on August 20 and 21, about seventy parasitized eggs were found, and about an equal number from which the parasites had issued; no doubt some were overlooked. But few of the pears showed traces of worms of the first brood, yet nearly all contained eggs of the second brood and very often more than one. As many as eleven eggs were found upon a single pear. One was found on the stem, six on the pear surrounding the stem, two on the upper half and the other two near the calyx. Of these, two contained parasites, one of which had issued, two were still fresh, and the rest had hatched. I should note here that the pears had been taken off three days previously. In other pears with less eggs, as many as three and even four young larvæ were found. The eggs found upon pears were most numerous near the stem, the others almost invariably on the upper surface of fruit, and but very few on the lower part or calyx. It was also observed that the young larvæ very rarely enter the fruit where an egg is deposited, but generally somewhat lower down, and in many instances instead of going to the center they leave their first mine after a few days and enter at the open calyx. On apples it appears they will oftener enter the fruit from the sides.

Many of the eggs of the first brood were destroyed by some enemy, what I could not learn. They had a brownish and shrunken appearance, and it is probable that they were destroyed by the Chrysopa larvæ, which were present in numbers upon the trees at the time. With the exception of these and the Coccinellid larvæ no other insects were observed in numbers likely to destroy the eggs. This was not observed to be the case with eggs of the second brood, at which time the predaceous larvæ mentioned had disappeared. The other three parasites bred during the summer are all from the chrysalids. The most efficient destroyer of Carpocapsa, however, is a small bat which is always in search of the moths, appearing somewhat later than the latter, but keeping up its chase until dark, when apparently the moths cease their flight and the bats go off in search of other food. Every night during June as many as six of these bats were to be seen flying around an isolated apple tree upon which there were a large number of the moths, not only taking the Carpocapsa on the wing, but very often darting at a

*This parasite is a species of the genus *Trichogramma*.—C. V. R.

leaf to get the resting moth. Of not less value is the larva of a Neuropterous insect, a Raphidia, which is present in numbers. Its long and flat structure together with its activeness enables it to hunt up any larva that may be present under bark or in crevices of the tree.

Not only is the larva devoured but the chrysalis likewise, and without doubt often the mature moth. It was indeed very hard work to find any larvæ or pupæ of Carpocapsa upon trees where the larvæ of Raphidia were present, and the latter occurred upon nearly every tree. As a rule, not more two or three could be found upon one tree by breaking off all the loose bark and examining the crevices, and often none at all. These larvæ are always on the lookout for food, crawling up and down the trees, but being chiefly concealed by the bark. Away from the trunk of the tree, however, more larvæ are found. An old and partly decayed stump or piece of wood lying anywhere near an infested tree will always be full of them; and, as has before been pointed out, many of the larvæ of the first brood, at least, spin up in the dry ground. I will again refer to the Dermestid larvæ mentioned before, not only as destroying the pupa of Carpocapsa but likewise the larva, during the summer season at least. Many apparently sound cocoons when cut open will be shown to contain larvæ and skins of some of these beetles. The contents have been devoured while there is no visible hole in the cocoon, showing that the larva had entered while young. This alone would not be sufficient evidence, but I have also found small larvæ of *Trogoderma tarsale* within the cocoons, and with the larvæ, dead and living, of Carpocapsa.

In two instances the half dead Carpocapsa larvæ showed small holes in their sides which had partly healed up. These no doubt were made by the Dermestid larvæ, which as a rule feed upon dry insect remains, and only kill living larvæ gradually by feeding upon the skin only at first. In many cases they were found with larvæ that had recently died, having already undergone several molts within the cocoons of the last larvæ. They are very abundant, especially around Alameda, as many as four or five large larvæ being often found within the cocoon and feeding upon the dead pupa of *Leucarctia acræa.* In almost any old egg-mass of Orgyia they are found. Whether they will feed upon the eggs or not I have as yet no evidence. Insect collections are not as much troubled by these beetles in California, especially in the valleys, as in the Eastern States. I have often observed them, however, to infest collections in the mountainous districts. A coleopterous (Clerid?) larva was recently found in the Sonoma Valley feeding upon Carpocapsa, but has not yet been bred. Numerous Carabid beetles were always found at the base of trees awaiting their chance to get a bite at the Carpocapsa larvæ. The most numerous of these were *Pterostichus californicus* Dej. and *Calathus ruficollis* Dej. A bright light with a white sheet below and behind was kept burning near the orchard in the Santa Cruz Mountains while the moths were abundant. One female

only was caught in this about one hour after dusk. Never before during my fourteen years of collecting moths with lights, sweeps, etc., have I, within my memory, collected a single Carpocapsa.

THE HESSIAN FLY.

(*Cecidomyia destructor.*)

This insect has been quite abundant and destructive to grain in the central part of the State during the season. A Mt. Eden correspondent wrote to the *Oakland Engineer*, May 2, as follows:

The Hessian fly has done irreparable damage to the grain in this vicinity. There has been hardly a field that has not been attacked. The prospect for a large barley crop is very good. The wheat crop will be a comparative failure. What is left from the Hessian fly is being destroyed by the rust.

Personally, until this spring, I have had no opportunity of making any observations upon this insect. On May 26, while in the Santa Cruz Mountains, it was noticed that some of the barley had fallen to the ground. On examination, puparia of the Hessian fly were found in places where the straw was fallen. The insect was found at the time in all stages from young larvæ to puparia, and some of the latter had recently hatched. From puparia collected at the time, flies made their appearance until the beginning of July. Other puparia collected about July 1 have not hatched up to date, and the insects are still in the larval state within the puparia. A few specimens of parasites (*Merisus destructor*) were bred from these, and from the same straws several specimens of an *Isosoma.*

During September, 1887, I found puparia, which I took to be those of the Hessian fly, on two species of grasses near here. These were forwarded to Washington, where they arrived in good condition, as stated in letter of October 3d, and the grasses were determined as *Elymus americanus* and *Agrostis* sp. Again during the summer I found the puparia upon several species of grasses in the Santa Cruz Mountains. I shall be prepared next season to give a list of grasses upon which the Hessian fly is found, and also more accurate notes as to the habits of this insect, which, as it would appear, is a very old resident of this coast.

JOINT-WORMS.

(*Isosoma* sp.)

These insects have been abundant and destructive in most wheat-growing sections, and they will continue to be numerous until stricter measures are employed for burning the straw and stubble.

LOCUSTS.

These did not appear in any large numbers except in the northern part of the State and, from some accounts, in Oregon. On my visit to Shasta Valley, Siskiyou County, at the end of July, locusts were no-

ticed in large numbers north of Edgewood and throughout that valley. At Montague I was informed that, on account of the unusually dry season and the crickets and grasshoppers, the crop had been an entire failure in that district. Around this latter place no vegetation except a few sage-bushes were visible. Along the creeks, where a little grass and vegetation was still growing, the locusts were swarming. *Dissosteira obliterata* Thos. was abundant throughout the valley. Even in places where for a half a mile not a shrub or any dry plant was visible they appeared to be happy, but were seen abundantly along water-courses and places still affording some food. *Melanoplus cinereus* Scudd. was more numerously represented in places where food was still to be had, even if dry. But few specimems of *M. femur-rubrum* DeGeer were seen, while *M. packardii* Scudd. was the most abundant of all, feeding upon grasses along streams, and in all the meadows, where it outnumbers all the other species put together. Here they were often observed, always the female, caught in the web of a large spider, which feeds upon them.

M. devastator Scudd. was not met with throughout the summer, while *Camnula pellucida* Scudd. was only seen occasionally in the places visited. Another numerous species in the Shasta Valley was *Hesperotettix pacificus* Bruner, but this was found feeding upon sage-bushes only. About eight other species of locusts were found at Montague, of which *Dissosteira carolina* Linn., *Trimerotropis fallax* Sauss., *Conozora wallula* Scudd., and *Stenobothrus coloradus* Thos., were the most abundant. Two species of large crickets have been very numerous at Montague also joining in the destructive work—*Anabrus simplex* (?) Hald., and the other a species of *Steiroxis*. The common cricket, *Gryllus luctuosus* Serv., was abundant in the central part of the State, often coming in large numbers into cities and into houses.

REPORT ON NEBRASKA INSECTS.

By LAWRENCE BRUNER, *Special Agent.*

LETTER OF TRANSMITTAL.

LINCOLN, NEBR., *Nov.* 20, 1889.

SIR: In presenting a report on the insect injuries in Nebraska for the past spring and summer, it is not my intention to mention all the species that have been observed in the act of depredating. Neither do I expect to enter upon a discussion of their life histories. To do this would require altogether too much time and occupy considerable more space than could be allotted to such insects as have been repeatedly described in your various reports upon injurious insects. Suffice it, then, for me to mention briefly a few of the species that most attracted my attention, either by their appearance in unusual numbers, their more than ordinary injuries, or by their peculiar mode of attack.

During the year most of the well-known species that are always present in more or less injurious numbers, were noticed at their regular seasons of appearance. These were, of course, expected; and, unless either very numerous or scarce, were but little noticed. Aside from these, few new or original observations were made during the active season; but several new enemies were observed to act in connection with old and well-known forms.

Since my last report, some time has been devoted to the *Acrididæ* of North America, in the continuance of our work upon that family of the order Orthoptera. The latter work was chiefly in the line of looking up the matter of distribution, the characterizing of new material, and the massing of such additional species as could conveniently be obtained without expense to the Department. Some little was also done in this connection in the study of several minor locust outbreaks in different parts of the country, as, for example, in Utah, Minnesota, and the White Mountain district of the New England States. Of these different outbreaks you already have been advised; Mr. Otto Lugger, of the Minnesota Experiment Station, reporting on that of his State; Mr. C. L. Marlatt, that of New Hampshire, and myself upon that of Utah.

LAWRENCE BRUNER.

Prof. C. V. RILEY,
U. S. Entomologist.

FALSE CHINCH BUGS.

Early in the year, during the month of May, two or three species of small hemipterous insects began to gather upon several farms just outside the city limits of Lincoln. These appeared in much larger numbers than is usual for the insects under consideration; and from their size,

order, and general appearance were mistaken for the chinch-bug (*Micropus leucopterus*) by many of the residents. This mistaken identity in the case of these insects was the occasion for much apprehension, as it well might have been had that insect put in its appearance in such great numbers so early in the year. These "false chinch-bugs," for such they were, began work by attacking the weeds and everything else that was green growing in the fields which were infested. The weeds soon disappeared and the insects transferred their attention to apple, catalpa, mulberry, and other small trees. But by far the greatest injury was done to grape-vines. They were all small, and were kept divested of every vestige of new growth for a time, and looked as if the vines never would be green.

The three insects which united in these demonstrations were the following: the False Chinch-bug (*Nysius angustatus*), the Purslane bug (*Geocoris bullata*), and a species that is quite common here in the West among various rank-growing herbs and weed-like plants, and is known to the entomologist as *Trapezonotus nebulosus.*

The first named of these was by far the most numerous, and if working singly would have occasioned nearly the same amount of damage as did the three. The second and the last named were present in nearly equal numbers, perhaps the last being the commoner of the two. All three species gathered upon the main stems and larger branches of the trees and even in clusters upon the scattered remnants of the last year's vegetation. They were pretty well scattered over the fields, but appeared to be most numerous upon some hill-slopes where they had been attracted during early spring and late fall by the warm sunshine. These clusters of bugs were composed of individuals of all ages and sizes, ranging from those apparently but a few days old to those fully matured and winged. An investigation soon disclosed the reason for their abundance in this particular locality. Last year these fields had been permitted to grow up in weeds after the spring cultivation. These weeds, purslane, tickle-grass, stink-grass, and tumble-weeds, made a splendid retreat for the bugs to gather, feed, and breed in, and afterwards to winter in. The present spring being dry weeds and grasses were slow in starting. Not so with the bugs. Eggs were laid at the usual time, these hatched and the little bugs soon exhausted what green vegetation there was for them to feed upon, and which was very slow in appearing on account of lack of the necessary amount of moisture. The trees and vines being deeper rooted sent out their buds and green leaves. These attracted the hungry hordes of bugs, and were at once attacked in bud, leaf, and stem, the bugs inserting their beaks and extracting the sap. The consequence was the injury spoken of above.

As a remedy against the destruction of the grape-vines I suggested covering the vines, which were small ones, with dirt for a week or ten days until weeds had an opportunity to grow, after which time there would no longer be danger, and as a preventive for the future to keep down the weeds in late summer, especially when the season is a dry one.

In habit these three bugs resemble the Chinch Bug to a considerable degree, only that they are earlier in their egg-laying, and that their food-plants are weeds and other herbaceous plants, rather than grasses. They also move about on the wing in a similar manner to that of the *Micropus leucopterus*. Last spring, on one day in particular, the air was full of these and other small hemipterous insects. At just what date this flight occurred I do not remember now, but know it was during the month of May.

The three species referred to above in connection with the injuries recorded, all occur upon ground that has been neglected and allowed to grow up to purslane and Amaranthus. The two latter named are also occasionally found about smart-weed (*Polygonum*) during late summer and fall, while the first mentioned is also inclined to be partial to "stink" grass at times.

CUT-WORMS.

Scarcely a year passes without a report of damages from cut-worms in various parts of the country. Here in Nebraska quite a large number of the night-flying moths belonging to the genera *Agrotis*, *Hadena*, *Mamestra*, etc., are often the cause of much worry and not infrequently the loss of much time and money to the farmer and gardener.

At about the same time that the bugs mentioned above were the most plentiful and doing their injury to trees, vines, etc., the reports of cut-worm depredations began coming in to the station from various districts within and without the city limits. These reports included injuries to both garden and field crops, and from the fact that they were received from widely separated localities, the pest was quite general over the eastern part of the State. Specimens of at least a half dozen distinct species of the worms were received by me, along with the statement that they were the authors of the injury. Among these I recognized *Agrotis annexa*, *A. suffusa*, *A. messoria*, *A. saucia*, and *A. clandestina*.

So abundant were several species of these worms that they literally cultivated the ground at places where they burrowed during day-time. Nor did the worms content themselves with feeding upon cultivated plants alone, but also, in many instances, kept down the weeds. Here in the city of Lincoln, upon a vacant square that had been used by the boys as a base-ball ground, and where the ordinary "pepper-grass" was growing in profusion, the *Agrotis annexa* finally succeeded in clearing the ground of this weed. So voracious did the worms become before maturity that the pepper-grass was even cut off and the stems drawn into their retreats in the ground, where they might be devoured during day-time. On cloudy days the worms even ventured forth to feed openly by daylight, scurrying back into their holes when the sun came out for a moment. In the hard trampled ground their holes were smooth-cut and presented a very interesting sight indeed when the occupants issued forth and quickly returned upon the least disturbance, like

some animal of greater intelligence. The larva of this particular species of *Agrotis* is exceedingly active, reminding one not a little of some of the chipmunks among the rodents.

A second species that much interested me is the larva of an *Agrotis* sp. that was exceedingly numerous upon the college farm and adjoining tracts to the eastward of the city. This latter worm worked on various plants in the garden, but on the farm showed decided taste for clover. Here it literally "lived in clover" in large numbers. The different kinds of clover growing in the experimental plats suffered much. It was here that one of the instances above cited of cut-worms cultivating the soil occurred.

The remedies used against these different cut-worms varied somewhat in their character; but they were chiefly hand picked or crushed. Many of the worms also perished from the attacks of predaceous beetles either in the larval or imago stages, and of parasites of one or another sort. A few of them also from diseases that resulted from the presence of fungi or bacteria. The parasitized worms were the result of the eggs laid by Tachina flies in most cases. The *A. annexa* larvæ suffered most in this respect, on account of their habit of coming out to feed during the day-time.

ARMY-WORM.

As the State grows older in its settlement the reports of Army-worm depredations become more frequent year by year. Last year I reported the appearance and damage by this insect in the extreme northwestern part of Nebraska, as well as in portions of southwestern Dakota. During the present year several localities in northeastern Nebraska were overrun to a limited extent by the larvæ of *Leucania unipuncta*. None of these areas infested were of very great extent, nor was the injury committed complete in any of the cases coming to my notice. Millet and oat fields were the chief sufferers.

A small black fly was bred from larvæ received from Mr. J. M. Seymore, of Pender, Thurston County. This fly has frequently been observed by me at various points in northern Nebraska, where I have taken it in my net when sweeping for other insects on the prairie. It must be a regular enemy of *Leucania unipuncta*, and perhaps also of other allied species, since it is by no means an uncommon insect every year. Others of the flesh-flies (Tachinidæ) also act as guards against this insect's rapid increase, as can readily be seen from the fact that many of the larvæ taken have the eggs of these flies attached to their bodies.

Visiting again this year the region last year reported to you as having the insect present in injurious numbers I was pleased to find that the Leucania had not appeared in numbers sufficiently great to attract the attention of those persons who lost crops by their depredations last year. In fact I am pretty confident in asserting that there are no grounds for fearing this insect next year, in the State of Nebraska at least.

THE GREEN-LINED MAPLE-WORM.

For the third time, now, many of our soft maple trees in the city of Lincoln have been entirely defoliated by the larvæ of *Anisota rubicunda.* This insect has been steadily increasing for the past three years, and if it does not soon die off by some epidemic disease or is killed by parasites the growing of this tree will be very difficult. This state of affairs is due entirely to the negligence of our citizens in general, who, it appears, can not be induced to spend the little time necessary for the destruction of insect pests that attack their shade trees, garden and farm produce, and flowering plants. The entomologist can not kill all the insects, good and bad, in the country; neither are his words of advice heeded in the least when he tells how each insect enemy is to be gotten rid of by means of the least labor and expense to those who should be most interested.

THE BLUE-GRASS WEEVIL.

For the past two years *Sphenophorus parvulus* Gyll. has been increasing quite rapidly in numbers, so that now it has come to be one of our commonest beetles in the city of Lincoln, at least, if not elsewhere. From the fact of its frequenting sidewalks, or being concealed under boards, sticks, and stones that were left lying about on the University campus, and on lawns elsewhere in the city, I began an investigation as to its probable breeding place. This study has led to the discovery of its feeding upon the roots of the common blue-grass (*Poa pratensis*). So plentiful has the insect become in some lawns that the sod has been entirely killed over large patches.

The larva is a short, thick, whitish grub, like those of other species of the genus, and measures from 4 to 5 millimeters in length when fully matured. The beetles appear twice a year, *i. e.*, in the spring and early fall, the insect probably being double-brooded. Some of the beetles may come out in fall, while the remainder may lie over winter as pupæ. The fully matured larvæ were found early in June, while others were observed last October. Damp and well-watered lawns appear to be infested fully as badly, if not worse, that those that are dryer, although they do not show the injury nearly so quickly in the former as in the latter case.

While looking for larvæ during the latter part of last May, numerous specimens of a small white "hair-worm" *Mermis* or *Gordius*, or some allied genus, were found scattered through the soil. These were only obtained at very damp places under trees on the University campus, and as a rule were tightly coiled. Whether these would have or had been in any way connected with the Sphenophorus larvæ, I do not know, as I am not sufficiently well acquainted with these forms nor with their life-histories. Various ground-beetles (*Carabidæ*) and their larvæ certainly do devour the larvæ of Sphenophorus, since the former were also quite common in the localities where the latter abounded. No experi-

ments were carried on with a view to finding a remedy against the injuries of this weevil.

THE CORN ROOT-WORM.

(*Diabrotica longicornis.*)

This insect is becoming alarmingly common in the counties of eastern Nebraska and those of western Iowa; and, judging from the general food habits which the imago appears to be developing, it may soon become a much more dangerous pest than we at present imagine. During the past summer and fall the beetle has been almost omnipresent, so common was it in the vicinity of Lincoln. It was found upon a large variety of plants belonging to different orders. It was beaten from trees such as maple, box-elder, elm, ash, willow, cotton-wood, and oak. I found it rather common among the grasses and obtained it in plenty in gardens where it was feeding upon the leaves of radishes and turnips, in several instances completely riddling these latter with holes. As late as September 28, the beetle was still quite active during daytime, and quickly took to flight upon being disturbed. In August it was observed to be nocturnal in its movements, as was to be seen by the large numbers of the beetles that were attracted to and gathered about the electric lights. On the morning of the 15th, 260 specimens of the beetle were taken from the globe of a single arc light that hangs in front of University Hall upon the campus of the State University. These had all been attracted to and caught in the globe in a single night. Whether or not these came from the farms in the surrounding country I can not say. Might not the species work in the roots (for the larva is a root-borer) of some other plant or plants beside corn? At any rate it is my present intention to look into the life-history of the Corn Root-worm a little more closely during next season. It is getting to be by far too common an insect in these parts for us to be running chances in dealing with it. Rotation of crops may or may not always prove to be a remedy against its depredations.

INSECTS DETRIMENTAL TO THE GROWTH OF YOUNG TREES ON "TREE CLAIMS" IN NEBRASKA AND OTHER PORTIONS OF THE WEST.

For several years now I have been interested in the study of the insect pests that render the growing of young trees upon claims entered under the "timber-culture act" quite a difficult and tedious matter. This interest in the subject had its origin partly in personal experience and partly from the numerous complaints of others who have experienced great difficulty in securing a sufficient growth in their young timber within the limitations for making final proof. Not infrequently has it been the misfortune for those striving to gain titles to Government lands under this act to have their trees completely defoliated for several years in succession. Nor have these injuries been confined to any single kind of tree. Since commencing the study of the subject I have either

seen or heard of all of the following species suffering alike from this cause: Ash, Box Elder, Soft Maple, Cottonwood, and Willow. The honey locust, too, has been subject to defoliation by insect enemies when growing as hedges upon the uplands of the semi-arid regions west of the 97th meridian. Some of these trees thus attacked were killed outright, while others were set back a year or more by each defoliation.

Several different lines of investigation have been followed in the study of this subject, viz, the comparative freedom from insect attack of the various kinds of trees; the influence of topography upon the growth of each kind of tree, as well as upon the increase and development of the insect life thriving upon the tree; also the comparative abundance or absence of birds and parasitic insects in the different regions, and what relation these bear to insect depredations. Of course, when fully carried out in the several lines indicated above, the investigation of such a subject can not fail to be quite extensive and result in some good to the parties most concerned. For the present paper, however, only a few of the most important of these insect enemies will be mentioned, and then only cursorily. Of these there are about thirty species belonging to the orders Coleoptera, Hymenoptera, Lepidoptera, Orthoptera, and Hemiptera. Most of these insects that I wish to call attention to are quite general in their distribution, and therefore as well known to you as they are to those living in the "tree-claim" region. My report will then simply consist of a statement as to their abundance, distribution, and the amount of injury done by each species. To do this the following table will best express my wishes and at the same time be least cumbersome. All of the species therein mentioned have been either observed by myself or were reported by others as occurring in injurious numbers during different seasons upon tree-claims located in Nebraska, Kansas, and Dakota.

Insect.	Tree.	Insect.	Tree.
HYMENOPTERA.		*Cressonia juglandis* A. & S.	Walnut.
Cimbex americana Leach	Willows.	*Clisiocampa americana* Harr.	Most kinds.
Monophadnus barda Say	Ash.	*Clisiocampa sylvatica* Harr.	Do.
COLEOPTERA.		*Datana angusii* G. & R.	Black Walnut.
Lina scripta Fab	Willow and Cottonwood.	*Anisota rubicunda* Fab	Soft Maple.
		Hyphantria cunea Drury	All kinds.
Chrysomela sp	Do.	*Apatela populi* Riley	On Cottonwood.
Disonycha pennsylvanica Ill.	Willow.	Do	Willow.
		Do	Maple, Box Elder.
Chrysobothris femorata Fab.	Box Elder and Maple.	*Tortricid* (———)	Honey Locust.
		Sphinx	Ash.
Lachnosterna (several species).	All kinds.	Do	Elm.
Epicauta cinerea Forst	Honey Locust, Coffee Bean.	*Tortricid* (———)	Boring twigs of Hackberry, Box Elder.
LEPIDOPTERA.		ORTHOPTERA.	
Papilio turnus Linn	Ash.	*Œcanthus niveus* Serv	Stems of various trees.
Vanessa antiopa Linn	Willow, Elm.	*Œcanthus latipennis* Riley.	Stems not so common.
Platysamia cecropia Linn	Maple, Willow, Box Elder, etc.	*Melanoplus spretus* Thos	
Telea polyphemus Cramer	Maple, Elm, Box Elder, etc.	*Melanoplus femur-rubrum* DeGeer.	Foliage of all when numerous.
Triptogon modesta A. & S.	Willow, Cottonwood.	*Melanoplus differentialis* Thos.	

Almost all of the above named insects are sufficiently numerous at times, when working alone, to kill or at least to greatly retard the growth of the tree or trees upon which they feed. Of course, they do not all occur at once in any given locality in such overwhelming numbers, nor are the injuries the same every year; but quite frequently two or more of the species are found feeding in company upon the same tree in numbers sufficiently great to do harm. In addition to the species named above there are a great many others that are also known to attack and injure the trees growing upon tree-claims; but these latter have not yet made their presence so strongly felt as to force us to place them on the list of insect pests in connection with tree-claim culture. For a description and life history of many of these the reader is referred to Bulletin No. 7 of the United States Entomological Commission, entitled "Insects Injurious to Forest and Shade Trees."

Causes for these Insect Injuries.—There is a cause for everything, so in the present instance we must look for one or a combination of causes that work together in producing the undue increase of insect life upon the prairies when new varieties of plants are introduced. A very superficial survey of the ground will quickly reveal to us some of these causes.

In the first place, there are always a few dwarfed trees of most of the kinds that are usually planted upon claims. These trees are scattered along the water courses, in ravines and gulches, and a few other localities that are protected from the fires which have annually swept over the broad prairies for generations. These few trees furnish food for small colonies of the various species of insects that we have named. There are always enough of them to very quickly stock a claim close by upon which small trees are planted that are to their taste. Then, too, all of these injurious insects are of a hardy nature, used to a precarious life, and are strong fliers capable of making comparatively long journeys in search of food for themselves and their progeny. They are, in fact, the nomads of the insect world, capable of withstanding the vicissitudes belonging to a life upon the vast prairies where the more delicate parasitic forms could not live or even find shelter. Then, too, their requirements for quarters in which to pass the long, cold winter months are less complex than are those of the species that come later on.

In the second place, the country being destitute of groves of timber among the branches of which insectivorous birds can find shelter and build their nests most of these insect destroyers are absent. Of course, the absence of so great a factor as are these birds in the ridding a country of its insect pests soon becomes apparent in the increase of the latter and of the accompanying injury done by them. The absence of groves, too, not only keeps away the feathered tribe, but also prevents many of the more delicate parasitic and a large number of the predaceous insects from becoming established in the region. The majority of these latter forms of insects, as before stated, are such as require

sheltered retreats in which to lurk or to get away from the hot dry summers and the long cold winters.

In the third place, the comparative aridity of the region where these claims are located renders the growth of them somewhat slower than where the precipitation is more bountiful. This slowness of growth, while it is an advantage in one respect, aids the insect foes to a conderable extent in their work of destruction. A rank and rapid growth places a tree out of danger from external enemies much more quickly than will a slow growth. At the same time in rank growth a much greater amount of food is furnished for the same number of insects, and as a consequence less injury to the tree results than would were the growth slower.

A fourth cause for the rapid increase among these different insects in new regions is the absence of such fungoid diseases as are known to attack and kill various of these pests. After awhile, however, the germs of these diseases become diffused through the soil, vegetable débris, and about the encumbering growths, buildings, etc. These germs are carried around by the elements and other agencies, and in time some of them find lodgment within the bodies of such insects as are susceptible to their growth. The result is disease and death.

Comparative Freedom of different Trees from the Attacks of Insect Pests.—Up to the present writing I have not sufficiently investigated this portion of the subject to be entirely positive in my assertions as to the kind or kinds of trees most nearly exempt from the attacks of insect foes in different regions. None of them are entirely free; but that there are trees which suffer less than others in this respect is a well-known fact, and can be seen at any time where several kinds are growing side by side or in the same grove. Again, a particular kind of tree might be troubled in a given locality, while in another it would be comparatively free. Some trees also suffer while small, and others are usually injured after they have gained considerable growth and age. These variations with regard to insect attacks among different trees, and of the same kind at different ages, are governed by laws the explanation of which would require much more time and space than I have at my command. By looking over the list of insects mentioned above it will be seen that no reference is made of any species injuring either the Catalpa or Russian Mulberry. The Ash is affected by three, each of which at times strips it of foliage while young; the Box Elder by two or three; the Willow by a dozen or more; the Cottonwood by four or five; the Soft-Maple by several; the Elm a couple; the Honey Locust two, etc.

In treating this subject only such insects have been mentioned as have been ascertained to attack the various trees during their first few years of growth, and before they have attained any great size. Other species of insects injure these trees later on; but, as a rule, these latter

are less destructive to them save in a few instances. Only a very few borers work in healthy young trees in this region.

Remedies tried and suggested.—Only a few remedies have been generally tried against these pests in the region of tree claims, and most of these were confined to the various methods of "hand-picking" and crushing. Spraying and dusting with poisons and kerosene emulsions, or the use of road dust, ashes, air-slaked lime, etc., have been reported only in a very few instances. Any or all of these methods of warfare when properly carried on and used intelligently, in accordance with the habits of the insect that is being fought, will repay one for the time thus spent.

LOCUSTS OR GRASSHOPPERS.

Aside from several local outbreaks there has been no special damage done during the year by locusts within the United States. Of course, you are already acquainted with the particulars in connection with the local injuries, of which the chief are the following: The Rocky Mountain or migratory species at Nephi City, Utah; the same in Otter Tail County, Minnesota; and the lesser and red-thighed species in the mountain districts of the New England States. The Utah outbreak was partly investigated by me at the time (May) of its occurrence, through correspondence with the Hon. James B. Darton, of Nephi City. That gentleman supplied me with specimens at different times from which the insects under consideration were determined. The conclusions at which I then arrived were reported to Mr. Howard in your absence. If I remember rightly, both the Rocky Mountain (*Melanoplus spretus*) and the California locust (*Camnula pellucida*) were found among the material received from Mr. Darton. The Otter Tail outbreak has been very carefully written up by Mr. Otto Lugger, of the Minnesota Experiment Station; while Mr. C. L. Marlatt, of the Entomological Division, has reported on the New England outbreak.

While it is not my intention to devote much time to the subject of locust abundance and injuries, I do wish to say a few words concerning the fungoid disease known as *Entomophthora calopteni* of Bessey. During the present summer this disease has been unusually abundant in and around the city of Lincoln, Nebr. Several species of our native locusts were attacked by it; but the large yellow one, known as the *Melanoplus differentialis* Thomas, was destroyed by the thousands. Whether the fungus in question was more plentiful than usual, and did its work of extermination more effectually than during previous summers; or, whether it was on account of my being surrounded by a number of students in botany, and located next door to the botanical laboratory, that attracted my attention to these, I do not know. The impression is, however, that the former is the true explanation. On the University campus alone, where *differentialis* hatched quite plentifully and began doing considerable injury to various small trees and

shrubs, there must have been several thousands of the hoppers destroyed by the disease. Soon after the locusts became fledged some of them were observed to die after first showing signs of disease. After the disease first became apparent among the locusts, it spread, or at least appeared in other portions of the city, the number of dead and dying locusts increasing daily. So fatal did the disease finally become upon the University campus that but few of the *differentialis* escaped to deposit eggs. I know that three or four of the botanical students each collected the dead locusts by the chalk-box full to use as specimens in their line of work, and for exchange, while I gathered many of them myself. During the latter half of August, and early in September, at almost any time one might have secured from fifty to a hundred or more specimens of the dead locusts in a few moments, by simply going outside of the science hall a few yards.

So rapid was the final action of the *Entomophthora* (or *Empusa*, as it has more recently been called) that not infrequently the locusts were found still in copulation, one or the other of the sex being dead. When they were found in this condition, the female, though not always, was the first to succumb. This would not, however, prove anything as to the comparative fatality of the disease as far as the different sexes are concerned. There are other matters to be taken into consideration before we can come to a definite solution of comparative immunity from attacks upon the different sexes of an insect by a disease like the present.

Just how long a time is required for the full development of the fungus after an insect is first attacked I am not prepared to state; neither can I give an account of the various stages through which the fungus passes during this development from the original spore to the stage where such spores are reproduced. Nor am I posted as to all symptoms present during the different stages of the disease occasioned by the fungus within the tissues of a living locust. All that I know is, that shortly before death the stricken hopper climbs up some stick, weed, or blade of grass, to which it clings frantically with its anterior and middle pairs of legs. When found dead these always have their head uppermost.

Whether or not invariably fatal I can not say; and imagine that to ascertain this would be no easy task. I am also quite ignorant in reference to its capability of being artificially spread, since I have had no opportunity to experiment in that direction. Besides, the disease does not appear to be common to all species of locusts alike; or if it is, we do not know it. The subject will bear a much more careful study than has thus far been devoted to it. From an economic standpoint there is still a great deal to be learned concerning insect-attacking fungi, as a few recent experiments in this line clearly demonstrate.

Before leaving the subject of this locust-destroying fungus I wish to add the following notes, prepared for the present paper at my request

by Prof. C. E. Bessey. They will show the most recent views of botanists as to the systematic position of the plant in question:

Entomophthora calopteni Bessey.—The original description of this species appeared in the American Naturalist for December, 1883 (page 1280). It is reproduced here verbatim:

"I. Empusa stage, not seen.

"II. Tarichium stage: Oospores globular, or from pressure somewhat irregular in outline, colorless, 36 to 39μ. in diameter; walls thick (4μ.), colorless, smooth; protoplasm granular, after as if composed of many small cells, often with a large round vacuole. Occurring as a clay-colored mass in the body cavity and femora of *Caloptenus differentialis*.

"Ames, Iowa, August and September, 1883."

Specimens of this fungus collected in Wisconsin by Trelease and Seymour were distributed under the name given above by Ellis and Everhart in North American Fungi, No. 1801. In April, 1888, Mr. Roland Thaxter published, in the Memoirs of the Boston Society of Natural History, an important paper on The Entomophthoræ of the United States, in which he revises the species of the group, and adopts the older generic name *Empusa*, first proposed by Cohn in 1855, in preference to *Entomophthora* proposed by Fresenius in 1856. Moreover, Mr. Thaxter concludes that the fungus described above is identical with one described as *Entomophthora grylli*, by Fresenius, in 1856. Specimens of this species were distributed in 1885 by Dr. Farlow, in Ellis' North American Fungi, No. 1401. Our species thus appeared in Mr. Thaxter's paper under the name of *Empusa grylli* (Fres.) Nowakowski.

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 23.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

(PUBLISHED BY THE AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

WASHINGTON:
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1891.

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 3, 1891.

SIR: I have the honor to submit for publication Bulletin No. 23 of this Division. It comprises the reports of the field agents of the Division for the past year (1890), a summary of which has been included in your annual report.

Respectfully,

C. V. RILEY,
Entomologist.

HON. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The reports of the six permanent field agents of the Division are included in this bulletin. They are printed this year in full, but it should be understood that they are little more than summaries of the work in general performed by each one. Special reports upon specific subjects have from time to time been sent in by special direction, and these have been published in INSECT LIFE.

Mr. Lawrence Bruner, who last year reported upon the insects injurious to young trees on tree claims, has the present season devoted much of his attention to insects affecting, or liable to affect, the Sugar beet, a crop of growing importance in the State in which he is located. Although but one season's collecting has been done, some 64 species have been observed to prey upon this crop. As has been shown, nearly all of these can be readily kept in subjection by the use of the kerosene emulsion or the arsenites.

Mr. D. W. Coquillett's report is mainly devoted to methods and apparatus for the destruction of scale insects by means of fumigation. The experiments were aimed at the Red Scale, which is one of the most difficult to treat with washes. He describes the simplified tents, the rigging which enables them to be used rapidly, and shows the advantage of excluding the actinic rays of the light. Judging from recent California newspapers the use of this method of fighting scale-insects is rapidly increasing and the comparatively expensive apparatus is already owned by a large number of fruit-growers. This improved method is the legitimate outgrowth of experiments which we instituted at Los Angeles in 1887, and possesses the advantage over spraying that it can hardly be done in a slovenly manner. If used at all its effects are nearly complete.

Mr. Albert Koebele, while reporting upon a number of interesting fruit pests, notably the Tent Caterpillars of the Pacific slope, and a Noctuid larva which destroys the buds of certain fruit trees, devotes most of his report to the description of certain tests, which I directed him to make with different resin compounds against the Grape Phylloxera in the Sonoma Valley during September and October of the past year. The results have been fully as satisfactory as we anticipated, and the economy of the process is very striking, labor being practically the only expense.

Miss Mary E. Murtfeldt reports upon the insects of the season in eastern Missouri, and also gives the results of experiments which she has made with certain insecticides submitted to her from this office for trial. She also presents descriptions of four Microlepidoptera, which are new in the rôle of feeders upon Apple.

Prof. Herbert Osborn reports upon the insects injurious to forage-crops, meadows, and pastures in his State. His report last year was mainly taken up with the consideration of the Leaf-Hoppers, to which he gives some further consideration this year, adding some notes on locusts and crickets. He presents also a series of miscellaneous observations.

Mr. F. M. Webster devotes his report mainly to the Hessian Fly, discussing the number and development of broods, the effect of the larvæ upon plants, the effect of the weather on the development of the fall brood, and preventive measures. He also gives some notes upon three of the species of Plant-lice, found commonly upon wheat.

In presenting this bulletin for publication, I desire to thank these agents for the care with which they have followed out instructions and for the intelligent manner in which they have conducted these investigations.

C. V. R.

REPORT ON NEBRASKA INSECTS.

By LAWRENCE BRUNER.

LETTER OF SUBMITTAL.

LINCOLN, NEBR., *October* 16, 1890.

SIR: Herewith is submitted a report of my work in Nebraska for the year as special field agent of the Division of Entomology of the United States Department of Agriculture.

In addition to my observations on the general insect depredations within the State, I have incidentally given some time to the study of such insects as were taken upon the sugar and other beets during the summer.

This special study was undertaken at the suggestion of our experiment station director, who was quite anxious that "beet insects" should be made the subject of a special bulletin to be issued from the station some time during the coming winter. I accordingly include herewith a brief summary of the results of this special study.

Yours truly,

LAWRENCE BRUNER,
Field Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

The past summer has not been particularly noted as one in which insect depredators were especially abundant or destructive to the various crops that are raised in the State. In fact, taking the State as a whole, the injuries from this source have been rather less than is usually the case. No one species, so far as I have been informed, has been a pest during the year. The Corn Root-worm (*Diabrotica longicornis*), while it has spread some since my last report, was much less abundant than last year. Cut-worms did not appear in early summer so universally over the State, nor did they do anything near the damage they did the year past. No Army-worm depredations have been reported at the station, nor have any come to my own observation; while the Corn Ear-worm (*Heliothis armigera*) has been less destructive in most portions of the region along the Missouri River.

If any one insect has been on the increase and has caused more injury than usual, it was the almost universal Codling Moth (at least universal wherever apples are grown or eaten). But if this insect has become apparently more widespread within this region than it was

formerly, it is quite consoling to know that the warfare against it has also become more general. Almost every fruit-grower has at last come to the forced conclusion that warfare against this insect, at least, has become an absolute necessity, and has accordingly instituted a rigorous fight against it. The arsenious spray is the almost universal remedy resorted to with our fruit-growers here in Nebraska, as it is in other localities. Either London purple or Paris green are the poisons used, and where applied properly always result favorably to the orchardist.

THE GREEN-STRIPED MAPLE WORM.

The Green-striped Maple-worm (*Anisota rubicunda*) appeared quite numerously again in the towns and cities of Nebraska, and has done much injury to the Soft Maples (*Acer saccharinum*) growing along their streets. Here in Lincoln, the first or spring brood of larvæ was sufficiently numerous to defoliate many of the largest trees before they had become fully matured, and in that manner proved to be quite effectual towards self-extermination. Many of the larvæ actually starved to death; while others were so weakened from starvation that they either died in the chrysalis state, or else were so exhausted when they emerged as moths that there was but little egg-laying for a second brood. Some of the neighboring cities and towns were less fortunate, and had a much more plentiful fall brood of the larvæ, and hence will be well supplied with the insect next spring unless something unforeseen prevents it.

Considerable has been done in the way of remedies by the citizens of Lincoln against the second brood. Many of the moths were gathered and destroyed before they had time to deposit their eggs and later on in the season spraying the trees with London purple and Paris green was resorted to with good results.

While a moderately dry summer usually has the tendency to increase the number of most of our injurious insects, several such years immediately following one another have the opposite effect. So it has been with the summer which has just closed. The drought was so very marked that even the more hardy insect life was sensibly affected by its severity. Such species as had been favored by the scarcity of their more frail parasites during several years of moderate drought, this year were themselves, to a certain degree, sensibly affected by its continuance and severity.

LOCUSTS OR GRASSHOPPERS.

Locusts or grasshoppers of several species were quite numerous in certain localities, especially in cities away from the destructive influence of fowls and such other predaceous animals as are always at hand in the country ready to "gobble up" various insects. These locusts did some damage, of course, but not nearly so much as was done by them

last year. Whether this decrease in their numbers has been due to parasites or to disease, I can not say.

One noticeable fact in connection with the subject of insect depredations, in this particular region at least, is the growing interest which the general public is taking, and the tendency on the part of the people to help themselves against this host of insect enemies which is assailing them on all sides. Whether this interest is traceable to any particular source, or whether necessity is the awakening factor, I can not say. I trust, though, that my work in this direction has not been entirely in vain.

BEET INSECTS.

Ever since the Sugar Beet industry was first agitated here in the West, and now especially since the project has assumed such a practical form, it has become of general interest. For several years now the cultivation of the sugar beet has been a theme for much speculation, and to some extent also of experimentation. Now that a large factory has been built at Grand Island in this State, the sugar beet is to be one of our regular crops year after year. It will no longer be a plant that is grown out of mere curiosity or simply for experimentation.

It has been ascertained in connection with the culture of the sugar beet that certain insects show a tendency to attack and injure it. In this respect the beet is not any different from other cultivated plants; or, for that matter, wild or native ones also. In fact, it is too evident that certain ones of these insect enemies seem to prefer this "new" crop to any of these which have been cultivated in the same region for a considerable time.

It was therefore thought here at the experiment station, early last summer, that it might be well, as far as practicable in connection with other lines of work, to give some attention to these insect enemies of the sugar beet. Accordingly the following "press bulletin" was sent out over the State:

SUGGESTIONS IN REGARD TO THE SUGAR-BEET CULTURE.

Reports from the sub-stations established in the spring by the State Experiment Station for the purpose of determining the effect of the varying conditions of the soil and climate on the growth of and the production of sugar in the Sugar beet are in the main good.

In many places, especially in the extreme western part of the State, beets have suffered from hot weather and a lack of rain; as a rule, though, they seem to withstand these unfavorable conditions as well as corn and better than small grain.

From some points reports tell us that insect enemies have begun their ravages. * * *

As there are several kinds of insects that attack the beet, and as they have already been reported as having begun operations, it seems the proper time to begin to learn something of their appearance, habits, and the best means of meeting their advances. To this end the beets should be watched very carefully, from day to day and at different times of the day, and even in the evening, for any insect, bug, or worm that seems to have an interest in them; search the leaves, pull up the beets and search the

roots and the top layer of the soil, and when any marauder is found send it to the experiment station for study and identification.

Directions for sending such specimens I copy from Bulletin XIV on "Insects Injurious to Young Trees on Tree Claims," just issued:

"Whenever possible, insects should be packed alive in some tight tin box—the tighter the better, as air-holes are not needed—along with a supply of their appropriate food sufficient to last them on the journey; otherwise they generally die on the road and shrivel up.

"Send as full an account as possible of their habits; what part of the plant they infest, time of day when they are most active, amount of damage done, etc.

"Packages should be marked with the name of the sender and should be addressed to the entomologist of the Agricultural Experiment Station, Lincoln, Nebr."

It will aid very materially in forming conclusions if all people who have planted seed this season will send from time to time reports of the conditions of their beets to the experiment station.

Address:

H. H. NICHOLSON,
Agricultural Experiment Station, Lincoln, Nebr.

The very dry summer may have had considerable to do towards influencing much of the insect injury to the beets grown within the region designated, and some species of insects may have worked upon this plant that ordinarily would not have done so. In many localities various insects were observed to congregate among the leaf stems just above the ground that could not have been there for mischief, since they were such forms as do not feed upon growing plants. Especially was this true in portions of the State where the drought was severest and where other refugees from the burning sun and parched soil were scarce or entirely wanting. In many of these localities a great variety of insect life was always sure to be found hidden away during the daytime in such places. Not only beetles but also representatives of such other orders as the Hymenoptera, Hemiptera, Neuroptera, Orthoptera, Diptera, and Lepidoptera were quite common in such localities. Even many water-inhabiting forms frequently occurred in company with the others.

Of course all of these insects that were found on or about the roots of the beets were sent in to the station both by the field agents and by the various correspondents, who took an interest in the investigations under way. To separate most of these "refugees" from such other forms as might possibly be there for mischief was, of course, quite easily done at the station by those who were accustomed to the habits of most of the insects under consideration. A few of them were, however, more difficult to single out, and required special study to decide positively, which in nearly every case was accomplished.

In the study of this subject it was quickly demonstrated that almost all of the insect enemies of the sugar beet, as well as of the common garden and other varieties, were either weed feeders or else were such as are very general feeders. It was also ascertained that nearly if not quite all of the insects of whatsoever description that attack other

Chenopodiaceous plants, as the various species of "tumble weeds," the "pig-weed," Atriplices, etc., the purslane and other juicy weeds, as also many of those that attack the various Cruciferæ and Solanaceæ, will also feed upon the beet. Not a single species of insect has thus far been reported by any of the agents of the station, or by correspondents, that is exclusively a beet feeder. Every one of them has been ascertained to attack some one or more of the other plants that are also common to the region. Only a very few species have appeared in numbers sufficiently great to be what could be termed "destructive" to the beet within the region covered by these studies or investigations; and these few are of such a nature that they can be readily combated.

In their modes of attack upon the beet these various insects, so far as they have been studied, are either leaf-feeders or root-borers, *i. e.*, they either attack the foliage which they devour or from which they suck the juices by inserting their beaks, or they bore into or gnaw the roots. Later on in our investigations we may find that there are others that will attack the seeds and seed stems. In either of the former cases the result is an injury to the beet, whether it is being cultivated for the table, for feeding to stock, or for the manufacture of sugar. Should future study reveal others that attack the seed of the beet these latter would of course be of direct injury to the seed industry since much seed will necessarily have to be raised to provide for the large crops that are required each year for sugar.

Having now become fully convinced that the cultivation of the Sugar Beet is not without its drawbacks here in the West, and that there are insects which we must contend against and overcome in raising this crop, as well as in the raising of corn, wheat, and potatoes, we see the necessity of beginning our fight at once if we would prevent much future loss. By prompt action in the beginning, when the enemies are few in numbers and less generally distributed, we will have a much easier time of it; besides, our losses from this cause will be infinitely smaller than if we neglect them and permit them to go on increasing and spreading unmolestedly.

The following list embraces all such species of insects as were either found to injure the beet here in Nebraska or else have been recorded by others as attacking this plant within the region referred to:

List of Beet Insects.

Species that attack the Leaves.

Lepidoptera.

1. *Spilosoma virginica*, Fab.—The larva of this very common insect, is one of the first noticed to injure the beet. It also infests a large number of other plants.
2. *Spilosoma isabella*, Abb.—The larva, like that of the preceding, attacks the beet and many of our common weeds.
3. *Mamestra picta*, Harr.—Larva occasionally attacks the leaves of beet and other garden plants.

4. *Eurycreon rantalis*, Guen.—The larva of this small Pyralid moth is one of our most destructive beet insects. It is the one usually known as the Garden Web-worm; and also attacks a number of other plants among which are the "Pig-weed," the tumble weed, purslane, etc.
5. *Mamestra trifolii*, Rott.—Larva quite common on beets; and sometimes doing considerable injury by gnawing away the leaves and the entire tops of small plants. Also a purslane insect.
6. *Plusia brassicæ*, Riley.—The larva occasionally attacks the beet, but more commonly the turnip, cabbage, and other Cruciferæ.
7. *Deilephila lineata*, Fab.—Larva found feeding on beet leaves in Lincoln, Nebr., by Mr. H. Marsland. A very common purslane insect.
8. *Copidryas gloveri*, G. and R.—Taken several times on the leaves of beets which it had eaten more or less. An abundant purslane moth.
9. *Agrotis*, spp.—Several species of these "cut-worms" are occasionally quite destructive to the beet while it is still small. They work more or less all summer, but are most destructive early in the year. They cut off the plant just at or a little below the surface of the ground. Some of them also work upon the leaves above the ground.
10. *Leucania unipuncta*, Haw.—The Army Worm, when it is abundant, does considerable damage to beets and other garden plants by eating their foliage.

4 = 11. *Botis posticata*, Grt.—The larva of this moth is said to be quite destructive to a number of plants here in the West. "In 1873 we found the larvæ feeding upon Helianthus, Ambrosia, potatoes, and beets, skeletonizing and ruining the plants for miles along the Neosho Valley and throughout Kansas," writes Professor Riley in the U. S. Agricultural Report for 1883.

ORTHOPTERA.

12. *Melanoplus femur-rubrum*, DeG.—Occasionally injuring the leaves of beets and other vegetables.
13. *M. atlanis*, Riley.—When common, a general feeder, at least upon the products of the garden and farm—beets of course included.
14. *M. spretus*, Thos.—Attacks the beet during times of invasions. Sometimes entirely eating away the leaves and portions of root that protrude from the ground.
15. *M. differentialis*, Thos.—When plentiful it occasionally does some injury to the foliage of the beet and other garden plants.
16. *M. bivittatus*, Say.—Where beets are planted on low ground or are growing close to some rank vegetation, it attacks their tops, but never does much damage.
17. *Dissosteira carolina*, Lin.—Found feeding upon the tops of sugar beets during the month of July, at McCook, Nebr.
18. *Trimerotropis latifasciata*, Scudd.—Taken in company with the preceding, also feeding on sugar beets.
19. *Spharagemon æquale*, Scudd.—Several specimens were received during the summer from McCook and Ravenna, Nebr., with the accompanying statement to the effect that they fed on the sugar beet.
20. *Pezotettix olivaceus*, Scudd.—I have seen this hopper in beet fields several times under such circumstances as led me to think it feeds upon that plant. It is also quite partial to Helianthus and Chenopodium.

COLEOPTERA.

21. *Diabrotica 12-punctata*, Oliv.—Quite common on the leaves of beets, which it injures by gnawing holes in them.
22. *Disonycha triangularis*, Say.—The beetle feeds upon the leaves of beets and other Chenopodiaceous plants. Sometimes quite common here in the West.

23. *D. cervicalis*, Lec.—Has similar habits to the preceding, but is less abundant.

24. *D. xanthomelæna*, Dalm.—Common on beets and other Chenopodiaceous plants, the leaves of which it riddles with holes.'

25. *D. crenicollis*, Say.—One of the 5-lined flea-beetles that occur here in moderate numbers; is also occasionally taken on beet leaves at Lincoln, Nebr.

26. *Systena frontalis*, Fab.—Found feeding upon beet leaves on the College farm, Lincoln, Nebr.; also on the leaves of *Hibiscus militaris* at West Point, Nebr.

27. *S. tæniata, var. blanda*, Melsh.—A very numerous species in all parts of the State from which beet-feeding insects have been received. It literally riddles the leaves of beets with pit-like holes, in some instances entirely destroying the leaves of quite large plants. I have also taken it upon white clover, purslane, and amaranthus. This is liable to be one of our most destructive beet insects here in the West, especially in Nebraska.

28. *Psylliodes convexior*, Lec.—Another of the flea-beetles that is very abundant on the leaves of beets in some portions of Nebraska, and which works in a somewhat similar manner to the preceding.

29. *Chætocnema denticulata*, Illig.—I found still another of our small flea-beetles at work on the beets growing on the State farm here at Lincoln, although in much fewer numbers than either of the two species preceding.

30. *Epitrix cucumeris*, Harr.—This small flea-beetle was found to be quite abundant at Ashland, Nebr., where it was taken by Mr. T. A. Williams, upon the potato, *Solanum nigrum*, and the beet, the leaves of all of which were more or less closely riddled with holes.

31. *Epicauta pennsylvanica*, DeG.—This black blister-beetle injures the leaves of quite a number of plants, prominent among which are the potato, "pigweed," and beet. It has been received at the station from central and western Nebraska as one of the most destructive insects attacking the plant.

32. *Epicauta cinerea*, Forst.—Another of these blister-beetles was found here at Lincoln by Mr. Herbert Marsland, who said it almost ruined a small bed of beets growing in his garden. I have also collected the same species from one of the wild beans and several other native plants.

33. *Epicauta maculata*, Say.—This insect has been received from Medicine Lodge, Kans., and from Grant and Neligh, Nebr., where it was found to injure the sugar beets by feeding on the leaves. It is a very common insect here in the West upon quite a number of the Chenopodiaceous plants, and especially upon the various species belonging to the genera Chenopodium and Atriplex.

34. *Epicauta vittata*, Fab.—This striped blister-beetle is also a beet insect; and has been received from Ogalalla, this State, where it was reported as doing much damage to sugar beets. It also is quite a general feeder. Among its food plants are to be mentioned the Solanaceæ, some of the Leguminosæ, and I have found it to be quite destructive to several of the Sagittariæ.

35. *Epicauta cinerea, var. marginata*.—This large black blister beetle also frequently gathers upon vegetables of different kinds in the semi-arid regions east of the Rocky Mountains, but chiefly upon beans. I have taken it on beets once or twice here in Nebraska.

36. *Cantharis nuttalli*, Say.—During the late summer and early fall of 1888 this insect was very destructive to garden plants, beets included, in the Black Hills of South Dakota. It also abounds in the western and northwestern parts of Nebraska.

37. *Colaspis brunnea*, Fab.—This small leaf beetle, which appears to be quite a general feeder, has been taken on several different occasions upon the beet both by myself and different ones of the field agents, and also by some of the correspondents.

38. *Epicærus imbricatus*, Say.—The Imbricated Snout-beetle has been known to attack the beet among the many other plants upon which it feeds. It is a general feeder.

39. *Centrinus penicillus*, Hbst.—Another of the Snout-bettles that attack the beets here in the West is the one known to the entomologist by the above name. It gnaws small holes in the leaf-stem, and when numerous does considerable harm to the plants attacked. Whether or not the insect breeds here I was unable to ascertain.
40. *C. perscitus*, Hbst.—Still a third species of weevil was found upon the beets growing on the State farm. It is a much commoner insect than *penicillus*, and works in a similar manner upon the leaf-stem.
41. *Apion*, sp.—This little Apion was taken on the leaves of beets here at Lincoln on two separate occasions.
42. *Doryphora* 10-*lineata*, Say.—The Colorado Potato-beetle was brought into my office at different times during the summer by those who reported its having been captured on the leaves of beet which it was "certainly eating."

HETEROPTERA.

43. *Blissus leucopterus*, Say.—The Chinch Bug has quite frequently been taken by me upon beet tops in company with several others of the plant bugs. Whether or not it was there only temporarily, I can not say; but suppose it was, since all of our leading economic entomologists assert that its food-plants are limited to the grasses.
44. *Piesma cinerea*, Say.—A very common bug on the beet and various others of the Chenopodiaceous plants. Sometimes doing much damage to the leaves of the former.
45. *Nysius angustatus*, Uhl.—Another bug that often gathers upon the beet and other garden plants is what is called the False Chinch-bug. When numerous it often does considerable harm to the plants which it attacks. It is also one of the weed insects that enjoys a wide range.
46. *Geocoris bullatus*, Say.—The Large-headed False Chinch-bug, or Purslane Bug, is also much addicted to infesting the beet here in Nebraska. In fact it has been received from all over the State as one of the commonest of insects infesting the beet. It is also a great weed bug.
47. *Trapezonotus nebulosus*, Fall.—This bug also frequents the beet and several other Chenopodiaceous plants. It is especially partial to the Pigweed (Chenopodium album) here in Nebraska.
48. *Emblethis arenarius*, Linn.—Taken several times on the beet in company with the preceding. This insect also is a frequenter of localities where *Chenopodium album* is growing. The species also occurs about the roots of "Stink Grass" (*Eragrostis major*).
49. *Lygus pratensis*, Linn.—Probably one of the most general feeders among the true bugs, and sometimes a very destructive enemy of the beet. It occurs throughout the entire North American continent in the temperate regions.
50. *Euthoctha galeator*, Fab.—This bug has also been taken several times on the beet in the vicinity of Lincoln, Nebr. I have collected it also from the wild cucumber (*Echinocystis lobata*).

HOMOPTERA.

51. *Agallia siccifolia*.—This little leaf-hopper, which seems to be especially partial to the different species of Amarantus and Chenopodium and allied weeds, is also equally fond of the beet, at least such would appear to be the fact, judging from the large numbers of the insect that are invariably to be found upon this plant all through the summer. It occurs in all stages.
52. *Immature forms only*.—Found in moderate numbers on the sugar beet at Grant, Nebr., a rather large leaf-hopper, which also occurs upon the Amarantus and Chenopodium.

53. *Allygus sp.*—This prettily marked leaf-hopper is very partial to *Chenopodium album*, on the under side of the leaves of which it breeds throughout the summer. This insect also attacks other species of the same genus, those of the genera Amarantus and Montilia, etc. Besides these it is very frequently found on the beet. Characteristic marks of its presence are the rather large purplish spots that are seen upon the leaves of plants that have been punctured by its beak.
54. *Erythroneura sp.*—Another small, slender, green leaf-hopper that is occasionally met with upon the beet.
55. *Athysanus* (? *sp.*).—Still another of these leaf-hoppers that is found upon the beet.
56. *Liburnia interlexta.*—There is still a sixth of these leaf-hoppers that has been taken on the beet here in Nebraska; and which presumably also does some injury to that plant by sucking its juices.
57. *Aphis atriplicis*, Linn.—Mr. T. A. Williams tells me that he has taken this plant-louse on the beet at Ashland, this State, where it was quite common during the year.
58. *Aphis cucumeris*, Forbes.—This past summer Mr. Williams also took what he determined to be the *Aphis cucumeris*, Forbes, breeding quite abundantly upon some beets that grew right by the side of some cucumber vines that had been infested by the same insect.
59. *Siphonophora pisi*, Kalt.—The same gentleman tells me that he has also taken the common garden aphid here at Lincoln, on the beet. He found it in the pupa and winged stages.

Species that attack the Root.

COLEOPTERA.

60. *Ligyrus gibbosus*, De G.—This beetle has been quite destructive to the sugar beet over limited areas towards the western part of the State during the present season. It attacks the root, into which the mature insect gnaws great holes, sometimes entirely imbedding itself. It worked most on old ground and where irrigation was resorted to. It worked on the roots from the surface to a considerable depth but most at about 3 or 4 inches below the surface. In some instances it reached a depth of fully 7 inches below the surface.
61. *Lachnosterna fusca*, Fröh.—Not unfrequently the common white grub attacks the roots of the beet, and does injury to the plant in that way. There are very likely several kinds of the "grub" that are concerned in these attacks, since almost every locality has its particular species of "June bug" that predominates in numbers.
62. *Wire Worms.*—Several of the larvæ of "snapping beetles," or click beetles, are also to be charged with injuring the roots of beets in some localities.
63. *Unknown larva.*—On two different occasions during the past summer I found beets that had been attacked by some unknown larva just below the surface of the ground, and from which the depredator had already escaped. The work resembled that of an insect that works in the roots of different "tumble weeds" and causes them to break off. The larvæ are rather short, thick, whitish grubs with brownish heads, about one-fourth of an inch in length, slightly largest in the middle; possibly the larva of some snout beetle.

UNCERTAIN.

64. *Silpha opaca*, Linn.—This insect has been taken several times by me in beet fields, and in gardens where beets were growing. In Europe the insect is said to be quite injurious to the beet crop, by attacking and devouring the leaves. Whether or not it has the same habit in this country I can not say.

In addition to the above list of insects that are known to actually attack one or the other varieties of beet there are several others that

have been taken so frequently upon that plant, and under such peculiar circumstances, that they, too, may prove to be its enemies. Among these latter I would mention several of the Eleodes, one Collops, and several Diptera.

REMEDIES THAT CAN BE USED AGAINST BEET INSECTS.

It will be quickly seen by any one who has taken the pains to go over the foregoing list, that in nearly every case, at least so far as mentioned here, the insect enemies of the beet are identical with those that work upon our common garden weeds, or else they are such as are very general feeders. It will also be observed that most of them are leaf-feeders; *i. e.*, they nearly all attack that portion of the plant above ground. These being the facts in the case, the remedies that at once suggest themselves are simple. A spray of some kind scattered over the plants will be effectual as well as economical. The beet tops are seldom utilized for food, either for man or beast. Hence for protection against insects with gnawing mouth parts that attack them an arsenical spray can be used, whilst for such as receive their nourishment by means of a sucking mouth the kerosene emulsion will answer the purpose. This latter remedy will also be effective against No. 27, as has been demonstrated by actual experiment by at least one of our correspondents, who writes that "The kerosene emulsion which you directed me to try on my beets against the flea-beetles was a perfect success."

A direct as well as useful remedy is the careful destruction of all such weeds as furnish food for the same insects that attack the beet. Clean culture in this case becomes doubly necessary. First, to prevent the appropriation by the weeds of nourishment that should be taken by the beets, and secondly, to give less room for the propagation of injurious insects.

REPORT ON VARIOUS METHODS FOR DESTROYING SCALE INSECTS.

By D. W. COQUILLETT, *Special Agent.*

LETTER OF SUBMITTAL.

LOS ANGELES, CAL., *October* 8, 1890.

SIR: I herewith submit my annual report for the season of 1890. The Australian lady-bird (*Vedalia cardinalis* Mulsant) recently introduced by this Division, successfully survived the winter unprotected out of doors, and as early as the month of March I was able to distribute several colonies to those requesting them. Lest this species, after exterminating the Fluted or Cottony-cushion Scale (*Icerya purchasi* Maskell) should become extinct on this coast, our State Board of Horticulture, at the suggestion of its president, Hon. Ellwood Cooper, has erected two propagating houses over two large orange trees belonging to Col. J. R. Dobbins, in the San Gabriel Valley; in these houses the Vedalias are to be propagated and distributed to those requiring them. At the present writing it is no easy matter to find a single living Icerya anywhere in this part of the State, although in the early part of the season they appeared in limited numbers in a great many places; later in the season the Vedalias also appeared in considerable numbers, and by sending colonies of these to the different localities where the Iceryas had appeared, the latter were effectually held in check.

The Red Scale (*Aspidiotus aurantii* Maskell), so destructive to Citrus trees in certain localities, is rapidly reduced in numbers through the agency of the treatment with hydrocyanic acid gas, described in my previous reports. This treatment is now being largely used for the above mentioned purpose, and is giving far better results than have ever been obtained by the use of any kind of a spray; numerous instances have occurred where, upon large Citrus trees treated with this gas, neither myself nor other parties were able to find a single living Red Scale, either upon the bark, leaves, or fruit—a result which so far as I am aware has *never* been obtained by the use of any kind of a spray. The cost of treating trees with the gas is scarcely greater than that of using a spray, while the method has been so greatly simplified that trees can now be treated with the gas very nearly as rapidly as they can be sprayed. I have not as yet learned that any person, or even a single domestic animal, has ever been accidentally injured either by the gas itself or by the materials used in producing it. All of the objections which at first were urged against the use of this gas—the danger of being poisoned by it or by the chemicals used, the great expense attached to its use, and the impracticability of operating the tents—have finally been overcome, and the treatment is now in successful operation.

In my last report I gave an account of the spraying of a number of orange trees at Orange according to instructions. These trees were not again sprayed until the lapse of a little over one year. At this latter date the trees were again badly infested

with the Red Scale (*Aspidiotus aurantii* Maskell), although these were not so numerous as they were at the time that I had them sprayed a little over one year previously. The oranges when gathered in the following spring were quite free from the scales, none of them having been rejected by the purchaser on account of being too badly infested with these pests. Those who depend upon spraying for ridding their trees of these scales usually spray their trees twice a year, in March or April, and again in August or September, although some growers perform these operations only in the autumn, the second spraying being given to the trees about two months after the first.

During the past season I have received numerous favors from you, especially in the matter of identifying insects, for all of which please accept thanks.

Respectfully yours,

D. W. COQUILLETT.

Prof. C. V. RILEY,
United States Entomologist.

THE GAS TREATMENT FOR THE RED SCALE.

The process of treating trees with hydrocyanic acid gas for the destruction of scale insects (Family Coccidæ) is now being extensively used in southern California, not only in the orange groves, but also in the nursery where the imported trees are subjected to this treatment for the purpose of ridding them of insect pests. In Orange County alone fully 20,000 orange and lemon trees have been subjected to this treatment the present year in order to free them from the red scale (*Aonidia aurantii* Maskell).

Since the year 1887 various accounts of this process have been published in some of the Annual Reports and Periodical Bulletins of this Department.*

But as these are somewhat scattered, and include an account of the various improvements that have been made from time to time, I have thought it desirable to give in this place a brief account of this process as at present used in actual field work, including in the account such improvements as have been made since writing up my last report upon this subject. Briefly speaking, this process consists in covering the infested tree with an air-tight tent and afterward charging the tent with hydrocyanic acid gas. The material commonly used in the construction of the tent is what is known as blue or brown drilling. A few persons have used common ducking in place of the drilling, but this is much inferior to the latter; in the ducking the threads of which it is composed extend only lengthwise and crosswise, whereas in the drilling they also extend diagonally—this belonging to the class of goods to which our merchants apply the term "twilled"—and for this reason the drilling is both stronger and closer in texture than the ducking.

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* See Annual Report United States Department of Agriculture for the year 1887, pp.123–142; and 1888, pp. 123–126. Also INSECT LIFE, vol. 1, pp. 41,42 and 286; and vol. II, p. 202–207.

After the tent is sewed up it is given a coat of black paint, as it has been ascertained that tents treated in this manner last longer than those which have been simply oiled with linseed oil. Some persons mix a small quantity of soap suds with the paint in order to render the latter more pliable when dry, and therefore less liable to crack. Instead of thus painting the tent some persons simply give it a coating made of an inferior grade of glue called "size," first dissolving this in water and then covering the tent with it, using a whitewash brush for this purpose. Sometimes a small quantity of whiting or chalk (carbonate of lime, $Ca\,Co_3$),is added to this sizing with or without the addition of lamp-black. A few make use of the mucilaginous juice of the common Cactus (*Opuntia engelmanni* Salm.) for this purpose; to obtain this the Cactus leaves or stems are cut or broken up into pieces, thrown into a barrel and covered with water, after which they are allowed to soak for three or four days; the liquid portion is then drawn off and is ready for use without further preparation. Tents which I saw that had been prepared with this substance were to all appearances as air-tight and pliable as when prepared in any other manner.

A tent 26 feet tall by 60 feet in circumference—a size large enough to cover the largest orange tree now growing in this State—if made out of drilling, and either painted or sized, as described above, will cost completed about $60. Where the trees to be treated are not more than 12 feet tall the tent can be placed over them by means of poles in the hands of three persons; to accomplish this, three iron rings are sewed to the tent at equal distances around and 6 or 7 feet from the bottom of the tent; immediately under each of these rings an iron hook is attached to the lower edge of the tent. When the latter is to be placed over a tree each of the hooks is fastened into the corresponding ring above it; one end of a pole is then inserted into each of these rings and the tent raised up and placed on the tree. The hooks are then released from the rings and the lower edge of the tent allowed to drop upon the ground.

Instead of allowing the tent to rest directly on the tree some growers use an umbrella-like arrangement, the handle of which is in two pieces, which are fastened together with clamps provided with pins; this allows the handle to be lengthened or shortened according to the height of the tree. This apparatus is put up over the tree and the tent allowed to rest upon it. By the use of this simple device the danger of breaking off the small twigs on the upper part of the tree by the weight of the tent is avoided. Mr. Leslie, of Orange, used four tents and tent-rests of this kind, and he informs me that with the aid of two men he fumigated 120 trees in one night. To remove the tent from one tree, place it over another, and charge the generator required only one minute and a half. In the place of poles some persons attach a circle of gas pipe to the lower edge of the tent; then two men, each taking hold of opposite sides of this circle, throw the tent over the tree. Dr. J. H. Dunn, of Pomona, informs me that four men, using six tents like the

above, fumigated 240 orange trees in one night, and that the average for each night was over 200 trees, the latter being 8 feet or less in height.

Trees over 12 feet tall will require a derrick of some kind for the purpose of putting on the tent and removing it again. For this purpose a stout mast is erected in the center of a strong framework mounted upon the running gears of a common farm wagon, the height of the mast depending upon the height of the trees to be operated upon. This mast is braced in four directions, and to the upper end of it is firmly attached a cross-piece, extending transversely to the length of the wagon, and long enough to reach from one row of trees to another. To each end of this cross-piece are attached small pulleys, through which pass ropes which are attached to the tents; by pulling down on these ropes the tents are drawn up to the cross piece after which the wagon is drawn ahead until the tents are directly over two of the trees to be treated; the ropes are then let out and the tents lowered down over the trees. The ropes are usually attached to the lower edge of the tents as well as to their apices, and when the tent is to be taken off of the tree the ropes attached to the bottom of it are first pulled downward, thus drawing the lower part of the tent up to the cross-piece first, and in a measure turning the tent inside out. But for this device it would be necessary to have the cross-piece at least twice the height of the trees to be operated upon. This apparatus is drawn between two rows of trees and the trees on each side of it treated with the gas. It is customary for the men themselves to draw the fumigator from tree to tree, thus doing away with the use of horses for this purpose. Stout planks are frequently used for the wheels of the fumigator to run upon. A fumigator of this kind, without the accompanying wagons and tents, can be built for about $15, it being the cheapest and simplest apparatus ever used for this purpose. It has not as yet been patented, and is more largely used at the present time than any other kind, operating the tents successfully even upon the largest orange trees. The first fumigator of this kind was built by Mr. O. H. Leefeld, a prominent orange-grower of Orange, and a man who has had considerable experience as a machinist.

Within the past few weeks a new kind of a fumigator has been brought out by Mr. W. H. Souther, of Covina, Los Angeles County, Cal. This, like the preceding one, is mounted upon a common farm wagon, and operates two tents, one on either side of it. At each end of this fumigator are four upright posts attached at their lower ends to the framework, which is mounted on the wagon; the outermost posts are shorter than the inner ones, and to the upper end of each is attached a long spar by a hinged joint, which allows the spar to be moved back and forth transversely to the length of the wagon. The two spars on one side of the fumigator are connected with each other near their upper ends by means of a wooden cross-piece, and are drawn back and forth

by means of ropes passing through pulleys. The tents are operated by means of ropes, which pass through pulleys attached to the spars and cross-pieces described above, there being five ropes attached to each tent; one of these is attached to the apex of the tent, and passes through a pulley fastened to the middle of the above-mentioned cross-piece; two other ropes are attached to opposite sides of the tent, about midway between its apex and base, and pass through pulleys fastened to each of the spars near their upper ends; the other two ropes are attached to opposite sides of the lower edge of the tent and pass through pulleys fastened to each of the spars a few feet higher up than those above described. To the bottom of the tent is attached a wooden circle in several pieces, and the two ropes attached to the bottom of the tent are fastened to this circle; these ropes are not exactly on opposite sides of the tent, the space between them equaling about one-third of the entire circumference of the lower edge of the tent.

In taking the tent off of a tree the two ropes attached to the tent midway between its base and apex are first drawn downward until their points of attachment are slightly above the top of the tree, after which the two ropes attached to the lower edge of the tent are drawn downward until their points of attachment are drawn up against the spars at the places where the pulleys through which these ropes pass are fastened; the lower edge of the tent at this stage will be perpendicular to the surface of the ground, and these ropes are further pulled upon until the spars on this side of the wagon are perpendicular to the wagon, thus bringing the weight of the tent upon the middle of the wagon; the spars are prevented from going over backward any farther by the presence of the inner upright posts referred to at the beginning of this description. When both of the tents have thus been drawn upon the wagon the latter is moved forward until the tents are brought opposite the next two trees. Before the tents are again let down over the trees the fumigator is first braced up by means of four long braces attached to each of the four corner posts at a distance of about 8 feet from the ground; these are attached in such a manner that they may be swung out at right angles to the fumigator, or, when not in use, may be swung around and loaded upon the wagon without first detaching them. After these four braces are in position the ropes attached to one of the tents are let out and the tent allowed to fall down over the tree, a guide-rope being attached to its lower edge to aid in guiding it in its downward descent over the tree.

Mr. Souther, the inventor of this fumigator, informs me that a fumigator of this kind, without the wagon and tents, could be built for about $60. He also informs me that a patent has been granted to him upon this fumigator.

Besides the above fumigators I may also mention one which has been used in a few instances with very good results. It is an extremely simple affair, consisting of an upright post the lower end of which is

attached to a framework on a wagon or sled, while to its upper end is attached a long stick of timber, the latter being attached near its middle to the top of the post, like the sweep of an old-fashioned well. The tent is then attached to one end of the sweep, and by pulling downward on the opposite end the tent is raised up, and may then be swung around and let down over a tree.

After the tent is placed over the tree the next step is to charge it with the gas. The materials used for the production of the gas consist of commercial sulphuric acid ($K_2 SO_4$), fused potassium cyanide (KCN), and water, the proportions being 1 fluid ounce of the acid, 1 ounce by weight of the dry cyanide, and 2 fluid ounces of water. The generator is placed under the tent at the base of the tree; it consists of a common open earthenware vessel. The water is first placed in the generator, then the acid, and last the cyanide, after which the operator withdraws to the outside of the tent and the bottom of the latter is fastened down by having a few shovelfuls of earth thrown upon it. The tent is allowed to remain over the tree for a period of from 15 to 30 minutes, according to the size of the tree.

It was found by experimenting that the trees were less liable to be injured by the gas when treated at night than they were when operated upon in day time, and at the same time the gas is just as fatal to the scale insects when applied at night as it would be if applied in the day time; and indeed it appears to be even more fatal when applied at night. This is accounted for by reason of the fact that in the day time the light and heat decompose the gas into other gases which, while being more hurtful to the trees, are not so fatal to insects. At night the trees are also more or less in a state of rest, and therefore are not so liable to be injured by the gas as they would be in the day time, when they are actively engaged in absorbing nourishment and replacing wasted tissue with new materials.

Of the different materials used in generating the gas, the most important is the potassium cyanide; of this there are three grades: The mining cyanide, commercial cyanide, and the C. P. (chemically pure). Of these three brands, the mining cyanide is wholly unsuitable for the production of the gas, and the C. P. is too expensive; the commercial brand (fused) is the only one that is used for producing the gas, but even this varies greatly in strength, containing all the way from 33 to 58 per cent. of pure potassium cyanide. It is, therefore, of the utmost importance that the operator should know the exact percentage of pure potassium cyanide that his cyanide contains, and when large quantities of it are purchased at one time it would be advisable to obtain one or more analyses of it by a reliable analytical chemist; or if it is not possible to submit the cyanide to such person, an analysis of it could be made by almost any person accustomed to the use of chemicals or drugs.

The only substance required for this purpose is the crystals of nitrate

of silver ($AgNO_3$), which may be obtained at almost any well-stocked drug store. Dissolve the nitrate in cold water contained in a glass or earthen vessel, using one-fourth of an ounce (Troy) of the crystals to 1 pint of water; this dissolves in a few minutes, forming a whitish, semi-transparent solution. The cyanide, when dissolved in water, forms a transparent, nearly colorless solution; when a small quantity of the nitrate of silver solution is added to this it at first spreads out in a white cloud, like milk, but it soon breaks up into small, white, floccy pieces which gradually disappear upon being agitated, leaving the solution nearly as transparent as at first; when more of the nitrate of silver solution is added from time to time the above process is repeated, except toward the last, when the cyanide solution becomes somewhat milky, but it still remains semitransparent, permitting the operator to see quite clearly the bottom of the vessel containing the solution. As soon as a sufficient quantity of the nitrate of silver solution has been added to the cyanide solution the latter immediately becomes white and opaque, like milk, completely concealing from view the bottom of the vessel containing it. This completes the operation, and the quantity of nitrate of silver solution used will indicate the strength of the cyanide tested. When absolutely pure, 5¾ grains of the potassium cyanide dissolved in water will require 1 fluid ounce of the above nitrate of silver solution before the turbidity occurs, indicating that the cyanide is 100 per cent. strong; if only one-half of a fluid ounce of the nitrate of silver solution produces this turbidity, this indicates that the cyanide in only half strength, or 50 per cent. strong; if only one-fourth of a fluid ounce is required, then the cyanide is 25 per cent. strong; and so forth. The nitrate of silver solution should be added to the cyanide solution very slowly, the latter being agitated by gently shaking it each time that any of the nitrate solution is added. Wherever any of the nitrate of silver solution comes in contact with the skin or nails of the hand it produces a reddish or black stain which can easily be removed by washing the stained part in a solution of potassium cyanide and water; this will quickly remove the stain without causing any injury to the parts affected, except, of course, when the stains occur upon a sore or cut in the hand, in which case it would be very dangerous to apply the cyanide to these places.

It sometimes happens that the percentage of cyanogen (CN or Cy) is given, instead of the percentage of potassium cyanide (KCN or KCy); but in cases of this kind the percentage of cyanide can be readily ascertained by always bearing in mind that two-fifths of a given quantity of potassium cyanide is cyanogen. Thus if a certain brand of cyanide contains 24 per cent of cyanogen, this is equivalent to 60 per cent of pure potassium cyanide. Potassium cyanide when absolutely pure (equal to 100 per cent.) contains 40 per cent. of cyanogen; and, therefore, no grade of cyanide could contain a larger percentage of cyanogen than this.

The potassium cyanide used for producing the hydrocyanic acid gas is principally manufactured by two firms: Power & Weightman, of Philadelphia, Pa., and the Mallinkrodt Chemical Works, of St. Louis, Mo. That made by the first named firm is the most largely used; when purchased by the ton the price is 36 cents per pound for the grade containing about 57 per cent of pure potassium cyanide, packages and carriage extra. It is put up in tin cans holding 10 pounds each, and also in barrels holding about 400 pounds each. That in the cans is much to be preferred, since the quantity in each is so small that it will soon be used up after the can is opened; whereas, the barrel containing so large a quantity, the cyanide used toward the last will have lost much of its strength by contact with the air. It is customary to weigh out the cyanide in small paper parcels, and mark each parcel with the number of ounces of cyanide that it contains; then when the tree is to be fumigated it is an easy matter for the operator to select one of the parcels containing a sufficient quantity of the cyanide for the tree, thus saving the trouble of weighing out the cyanide as it is to be used for each tree. As the fumigating is done only at night the weighing of the cyanide is frequently done by the ladies of the house upon the day preceding its use.

The quantity of cyanide to be used on each tree will, of course, depend not only upon the size of the tree but also upon the strength of the cyanide used. The following table will aid in determining the proper quantity of each ingredient to be used on different sized citrus trees, the cyanide being about 58 per cent pure:

Height of tree.	Diameter of tree-top.	Water.	Sulphuric acid.	Potassium cyanide.
Feet.	*Feet.*	*Fluid ozs.*	*Fluid ozs.*	*Ounces.*
6	4	¾	⅓	⅓
8	6	2	1	1
10	8	4½	2¼	2¼
12	10	8	4	4
12	14	16	8	8
14	10	10	5	5
14	14	19	9½	9½
16	12	16	8	8
16	16	29	14½	14½
18	14	26	13	13
20	16	36	18	18
22	18	52	26	26
24	20	66	33	33

Not only is this gas fatal to the Red scale (*Aspidiotus aurantii* Maskell), but also to the San José scale (*Aspidiotus perniciosus* Comstock), and indeed to all of the armored scales. It is also fatal to the Brown scale (*Lecanium hesperidum* Linn.) and to the Black scale (*Lecanium oleæ* Bernard), but the eggs of this species are not affected by it. The common Red Spider (*Tetranychus telarius* Linn.) and the Woolly Aphis (*Schizoneura lanigera* Hausmann) are also not affected by the gas when used strong enough to destroy the Red scale, although I have known it to prove fatal to true spiders (species not determined). House-flies (*Musca domestica* Linn.), Lace-winged flies (*Chrysopa* sp.?), and cer-

tain kinds of Ichneumon flies (*Ophion macrurum* Linn.) are also destroyed by the gas. On one occasion I obtained a cluster of eggs of a species of Psocus fly (*Cæcilius aurantiacus* Hagen) that were deposited upon a leaf of a tree before the latter had been treated with the gas, and from these eggs afterwards issued a number of parasitic flies belonging to the family Proctotrupidæ and to the genus *Alaptus*; but the species is as yet undescribed. Various kinds of Lady-birds, which are in the tree when the latter is treated with the gas, become stupefied and fall to the ground, but finally recover and are to all appearance none the worse for their temporary loss of consciousness. Birds, lizards, and even barn-yard fowls sometimes refuse to leave the large orange trees while the tent is being let down over them at night, and are therefore inclosed in the tent and subjected to the gas; the latter proves fatal to all of these. The small, pale yellow mites which are frequently found on orange trees, especially beneath the dead scales, are not affected by the gas; these have a general resemblance to the young of the Red scale, and several operators, finding these mites still alive after the tree had been subjected to the gas, came to the erroneous conclusion that the gas had not been effectual, thinking that these mites were the young of the Red scale.

From the above it will be seen that the gas treatment is not a sure specific for every kind of insect pest, but for destroying Red scales on citrus trees it is far superior to any other method at present known.

THE RESIN WASH FOR THE SAN JOSÉ SCALE.

During the past winter I carried on quite a series of experiments with various kinds of washes for the destruction of the San José scale (*Aspidiotus perniciosus* Comstock) on dormant deciduous trees, kindly placed at my disposal by Mr. C. H. Richardson, the inspector of fruit pests for the Pasadena district, Mr. Richardson also aiding me in making many of these experiments. Among all of the washes tried the following gave the best results:

Resin	pounds..	30
Caustic soda (70 per cent)	do....	9
Fish oil	pints..	4½
Water, enough to make	gallons..	100

For making 100 gallons of the above wash a kettle holding 30 gallons will be required. Place all of the ingredients in the kettle and cover with water to a depth of 4 or 5 inches, boil briskly for about 2 hours, or until it will dilute evenly with water, like black coffee, which it closely resembles in color. When this stage is reached the kettle should be filled up with water, adding this very slowly at first; the contents of the kettle can then be emptied into a tank or other vessel, and a sufficient quantity of water added to make 100 gallons. Care should be taken not to chill the wash by adding large quantities of cold water at one time.

The making of this wash will be greatly accelerated if the resin and caustic soda are first pulverized before being placed in the kettle; if in large pieces, a considerable length of time will be required in which to dissolve them. If a sufficient quantity of water is not used at first the materials when dissolved will form a thick, pasty mass, which simply breaks open in places to allow the steam to escape, and pieces of the mixture will be thrown out of the boiler or against its sides or lid by the escaping steam. When this occurs, water should be added until the solution boils up in a foamy mass. Whenever there is a tendency to boil over a small quantity of cold water should be added, but not too much, or the making of the solution will be retarded; after a few trials the operator will learn how much water to add in order to prevent the solution from boiling over and yet keep it in a brisk state of ebullition. If it is not desired to add all of the water at the same time that the solution is made, then enough can be added to equal two-fifths of the quantity required; the balance of the water can then be added at any subsequent time without again heating the solution. Thus, if a sufficient quantity of the solution is boiled to make when diluted 100 gallons, this could first be diluted to make only 40 gallons, and the remaining 60 gallons of water added at any time as required. If it is desired to use it in a still more concentrated form than this, it need not be diluted at all after it has been boiled sufficiently, but in this case it will be necessary to heat it again before adding the water.

On the 11th of February, between the hours of 1:30 and 4:20 p. m. (sun shining, light breeze), I had 60 dormant deciduous fruit trees sprayed with the above solution. These consisted of peach, plum, apple, pear, and quince trees; none of them had started to leaf out except the quince, which had put forth a few leaves at the tips of some of its branches. Each of these trees was infested with the San José scale (*Aspidiotus perniciosus* Comstock) and several of them had been almost killed by the attacks of this pest. April 23 I made a careful examination of these trees and found only a very few living San José scales; all of the trees except those which were nearly dead when sprayed were now making a vigorous growth. May 12 I again examined these trees, and found living San José scales on only three of them, about half a dozen scales on each. I made another examination on the 11th day of June, and found a few San José scales on some of the pears on the above trees. All of the Black scales (*Lecanium oleæ* Bernard) which I found on these trees were dead, and their eggs were dry. July 24 I again examined these trees and found three or four living San José scales on a few pears and apples on some of the trees, but the fruit was practically clean, whereas on adjoining trees which had not been sprayed nearly all of the pears were very badly infested with these scales. There was, however, a singular exception to this: A LeConte pear tree that stood in the midst of several Bartlett and Winter Nelis pear trees, which were very badly infested with the San José scale, was,

wholly free from this pest. Nor is this an isolated case, since I saw the same thing in another pear orchard located several miles from this one. Mr. Richardson informs me, however, that the fruit of this tree is almost worthless.

Wishing to test the effects of the above wash on growing trees, I sprayed a prune, peach, apricot, apple, and orange tree on the 12th day of May, between the hours of 10 and 11 a. m., sun shining, light breeze. I examined these on the 11th of June; on the prune all of the fruit had dropped off, and upon one-third of the leaves were dead brown spots, these spots not exceeding one-sixth of the entire surface of any of the leaves; on the peach all of the fruit was dead, but still clinging to the tree, and half the leaves had brown spots in them, these leaves being much more injured than were those on the prune tree; on the apricot the fruit was not injured in the least and three-fourths of the leaves were uninjured, but the remaining leaves had small brown spots in them, these spots not exceeding one-fifteenth of the surface on any of the leaves; on the apple all of the fruit had dropped off and half the leaves had large brown spots in them, these spots sometimes exceeding one-half of the entire surface of the leaf; on the orange nearly all of the fruit had dropped off (the young oranges being about half an inch in diameter), but the leaves were uninjured.

This indicates that of the different kinds of fruit thus experimented upon the apricot was the hardiest and was the least affected by the wash; next to the apricot is the orange, then the prune, after this the peach, the apple having suffered most from the effect of the wash.

The orange tree experimented upon was infested with the Yellow scale (*Aspidiotus citrinus*), and also with the Black scale (*Lecanium oleæ* Bernard), and all of these, as well as the eggs of the Black scale, were destroyed by the wash.

According to the scale of prices furnished me by the Los Angeles Soap Company of this city, the material for making 100 gallons of the above wash, when purchased in large quantities, would amount to $1.14, being but a trifle over 1 cent a gallon for the diluted wash.

The materials used in preparing the above wash are the same as those I used in spraying orange trees last season for the destruction of the Red scale (*Aspidiotus aurantii* Maskell), an account of which is given in my report to Professor Riley for last year, published in Bulletin No. 22 of the Division of Entomology (pp. 10–14); but the spray I then used was only three-fifths as strong as the one I used for the destruction of the San José scale as above described. On the 19th of December I tested the spray of the same strength that I had used for the Red scale on orange trees, but it did not prove fatal to all of the San José scales that it came in contact with.

The question as to the manner in which the above resin spray proves fatal to the scale insects—whether the caustic property imparted by the caustic soda is the destructive agent, or whether it is the suffocating

effect of the resin and fish oil saponified by the caustic soda that produces this result—is a very important one. Quite a number of our fruit growers were at first inclined to believe that it is the caustic property of the wash that destroys the scale insect, and they therefore increased the quantity of this particular ingredient, only to find that the wash so constituted is not apparently more fatal to the insects, while at the same time it is very liable to injure the fruit. My own studies and experiments lead me to believe that the above sprays kill for the most part by suffocation. In the course of experimenting I found that a wash composed of the following ingredients:

Caustic soda	pounds..	8
Resin	do....	33
Water enough to make	gallons..	100

did not prove fatal to as large a percentage of Red scale as did one consisting of:

Caustic soda	pounds..	6
Resin	do....	20
Fish oil	pints..	3
Water enough to make	gallons..	100

Now, if it is the caustic property of the wash that proves fatal to the scale insects, it is evident that the wash containing the largest amount of the caustic agent would prove fatal to the largest number of scale insects, but the reverse of this was really the case; the wash containing the smallest amount of the caustic agent, the caustic property of which was still further lessened by the addition of the oil, proved fatal to the largest number of the insects. On the other hand, the addition of the oil, while reducing the caustic property of the wash, would increase its varnishing qualities, since it is a fact well-known to painters that the addition of oil to a varnish improves its qualities. For these reasons it seems quite certain that it is the suffocating properties of the wash and not its caustic nature that cause it to prove fatal to the scale insects which have been sprayed with it.

I have seen orange trees that had been sprayed with a wash so caustic that it killed fully nine-tenths of the leaves on the trees, burnt the bark brown, and caused nearly all the oranges to drop off, and yet quite a number of the Red scale insects located on the oranges still remaining on the tree were alive. This will show the utter uselessness of attempting to destroy the Red scale on citrus trees by the use of caustic washes.

THE LIME, SALT, AND SULPHUR WASH FOR THE SAN JOSÉ SCALE.

For destroying the San José scale (*Aspidiotus perniciosus* Comstock) on dormant deciduous fruit trees many growers in this State use a wash composed of the following ingredients in the proportions here given:

Sulphur	pounds..	33
Lime	do....	42
Salt	do....	25
Water enough to make	gallons..	100

All the sulphur and half of the lime are placed in a kettle and 33 gallons of water added, after which the contents of the kettle are boiled briskly for about 1 hour; the solution will then be of a very dark brown color and having a reddish tint. All of the salt is added to the remaining 21 pounds of lime and the latter slaked, after which this slaked lime and salt are added to the above described sulphur and lime solution and the whole then diluted with a sufficient quantity of water to make 100 gallons; this is then strained, after which it is ready to be sprayed upon the trees.

This does not form a perfectly liquid solution but contains a considerable quantity of undissolved sulphur and lime, which soon settles to the bottom unless the solution is stirred almost constantly while being sprayed on the trees. It is therefore somewhat of the nature of a thin whitewash, and the trees sprayed with it have the appearance of having been whitewashed. On the 26th of November, at 12:45 p. m., sun shining, light breeze, I sprayed a pear tree with a wash made according to the above directions, the tree being very thickly infested with the San José scale. January 15 I found 14 living San José scales on this tree, and on the 23d of April I found several more; on the 11th of June I found on this tree a Black scale (*Lecanium oleæ* Bernard) containing healthy eggs.

I also tested this wash in the following proportions:

Sulphur	pounds..	50
Lime	do....	63
Salt	do....	37
Water enough to make	gallons..	100

This was applied to a pear tree at 1 p. m., November 26, sun shining, light breeze. On January 15 I found 6 living San José scales on this tree, and on the 23d I found several more.

At the time of making these tests there were several green leaves on each of these trees, but all of these were killed by the washes. The trees otherwise were not apparently injured, and in the following spring started into a vigorous growth which was continued throughout the summer. These trees were not over 10 feet tall, and were very thoroughly sprayed, so it seems quite certain that every scale insect located upon them must have been covered with the wash.

The philosophy of this wash is not at present clearly understood. It seems very probable however that the product of the lime and sulphur (bisulphide of lime, CaS_2) furnishes the insecticidal property, and the presence of the salt and slaked lime simply imparts permanency to the wash. I made quite a series of experiments with the above-named ingredients, with a view of ascertaining which of the ingredients were really insecticides, but these experiments have thus far resulted negatively. The following is a brief account of these experiments:

SALT.—Experiment 229: Table salt, 19 pounds; water, 100 gallons. I simply dissolved the salt in cold water and then sprayed the solution

on a pear tree at 12:30 p. m., November 26, sun shining, light breeze. This did not kill all of the green leaves that were upon the tree. January 15 I found a great many living San José scales on this tree.

Experiment 228: Salt, 38 pounds; water, 100 gallons. Dissolved the salt in water as before and sprayed on a pear tree at noon, November 26, sun shining, light breeze. This killed all of the green leaves that were upon the tree. January 15, I found many living San José scales on this tree.

Experiment 237: Salt, 60 pounds; water, 100 gallons. Dissolved the salt as before and sprayed on a pear tree at 10 a. m., January 20, sun shining, light breeze. April 23, I found a great many living San José scales on this tree.

SALT AND LIME.—Experiment 238: Salt, 25 pounds; slaked lime, 8½ pounds; water, 100 gallons. The salt and lime were added to the cold water, stirred occasionally, and strained through a piece of Swiss muslin and then sprayed upon a pear tree at 10:30 a. m., January 30, sun shining, light breeze. April 23 I found a great many living San José scales on this tree.

SALT AND SULPHUR.—Experiment 232: Salt, 25 pounds; sulphur, 75 pounds; water, enough to make 100 gallons. The sulphur was boiled for an hour in 75 gallons of water, after which the salt was added, and the solution diluted with a sufficient quantity of cold water to make 100 gallons. After standing for a few minutes the greater portion of the sulphur settled to the bottom, making it necessary to stir the solution almost constantly while applying it to the tree. Sprayed on a pear tree at 2:45 p. m., November 26, sun shining, light breeze; this killed all of the green leaves on the tree. January 15 I found a great many living San José scales on this tree.

SULPHUR.—Experiment 233: Sulphur, 100 pounds; water, enough to make 100 gallons. Placed the sulphur in the water and boiled for 1 hour, then when cold, sprayed the solution on a pear tree at 3 p. m. November 26, sun shining, light breeze. This did not injure any of the green leaves that were on the tree. January 15 I found a great many living San José scales on this tree, a smaller proportion being killed than in either of the preceding experiments.

LIME.—Experiment 239: Slaked lime, 10 pounds; water, enough to make 100 gallons. The lime was placed in the water, stirred occasionally and in two hours the solution was strained through a piece of thin Swiss muslin and sprayed upon a pear tree at 10:45 a. m. January 20, sun shining, light breeze. April 23, I found a great many living San José scales on this tree.

LIME AND SULPHUR.—Experiment 240: Quicklime (CaO), 100 pounds; sulphur, 33⅓ pounds; water, enough to make 100 gallons. Placed the lime and sulphur in a copper vessel, added 30 gallons of water, and boiled for two hours, then filtered. The solution was of a deep orange-red color. After standing for a few minutes needle-like crystals

somewhat resembling the down on the seeds of thistles separated out. These were composed of bisulphide of lime (CaS_2) and being freely soluble in water, were dissolved when the balance of the water was added. In this action all of the sulphur had been incorporated with the lime, since the residue when dried would not ignite. Added a sufficient quantity of water to the above solution and sprayed an apple tree with it at 10:30 a. m. March 18, sun shining, light breeze.

About 14 hours after making the above experiment it began to rain very gently and this was continued for 24 hours. April 23, I found a great many living San José scales on this tree. At the time of making the above test I also sprayed some of the solution on a branch of a peach tree in full blossom, but this did not appear to produce any injurious effect upon the blossom, since at the time of my visit on the 23d of April this branch bore as many peaches as did any of those I had not sprayed. It seems almost certain that the rain, coming on so soon after the wash was applied, rendered neutral the effect of the above solution on the scale insects sprayed with it. I have seen orange trees that had been sprayed with the resin wash on a certain day and a rain occurred during the night following the application; but the wash did not prove fatal to nearly as large a percentage of the red scales as would have been the case had no rain occurred.

On the same day that the above test was made (March 18), I also tried the above mentioned lime and sulphur solution at half strength, but it did not produce any apparent effect upon the San José scales infesting the tree sprayed with it. It was now too late in the season to make additional tests of this solution, but I hope to be able to follow up this subject during the coming winter.

From the above experiments it would appear that neither lime, salt, nor sulphur when used separately are effectual in destroying the San José scale; and the same is true in regard to any two of them when used in combination, except, perhaps, the lime and sulphur, which have not as yet been sufficiently tested. It is very probable, however, that these two ingredients give to the wash its insecticidal property, while the addition of the slaked lime and salt simply impart stability to the wash, rendering it less liable to be washed off the trees by the winter rains. Should this surmise prove correct, then the directions given at the head of this article for preparing this wash should be changed, an equal number of pounds of lime being required with the 33 pounds of sulphur, instead of only 21 pounds of lime, as at present used.

I experienced considerable difficulty in preparing and applying this wash, owing to the fact that some of the materials used are not soluble in water, necessitating an almost constant stirring of the solution while it is being sprayed upon the trees. On this account it is quite impossible to spray it uniformly upon all of the trees, and this difficulty has also been experienced by each of our fruit-growers who have used it and with whom I have conversed upon the subject, or who have written

to me in regard to it. Some of the trees sprayed by this solution would be very much whitened, as if whitewashed, whereas other trees sprayed from the same tank as these would be scarcely discolored by the wash. It is, of course, the slaked lime added to the solution that causes it to give the trees the appearance of having been whitewashed, since neither the salt nor the sulphur discolor the tree to any appreciable extent, and the same is true of the bisulphite of lime, which is produced by boiling the quicklime and sulphur together.

The cost of 100 gallons of this wash according to prices furnished me by Howell & Craig, wholesale grocers, of this city, for the sulphur and salt, and by the Southern California Lumber Company, also of this city, for the lime, is as follows, the materials being purchased in large quantities:

Sulphur, 33 pounds, at $2\frac{1}{8}$ cents per pound	$0.70
Lime, 42 pounds, at $\frac{7}{8}$ of a cent per pound	.33
Salt, 25 pounds, at $\frac{9}{20}$ of a cent per pound	.11
Total	$1.14

The salt quoted above is a poor grade, such as is used for salting hides, and the price quoted is by the ton; the sulphur is in sacks, and the lime in barrels containing about 220 pounds each.

Of the two washes above described—the resin, caustic soda, and fish oil, and the lime, salt, and sulphur washes—the one containing resin is greatly to be preferred. Not only is this wash easier to prepare than the other, but it is also much easier to apply it to the trees, since it is perfectly soluble in water and therefore does not require to be stirred while being sprayed upon the trees. For this reason more uniform results will be obtained by its use than would be obtained by using the sulphur wash. Moreover, the resin wash, by being properly diluted, can also be used in the summer season, and thus only one wash need be used at any time of the year. In my own experiments better results were obtained by the use of the resin wash than were produced by the sulphur wash. The price per gallon of each of these washes is about the same. The sulphur wash should never be used on trees in leaf nor on those just starting to leaf out, and this is also true of the resin wash when made according to the formula given in the preceding article.

MISCELLANEOUS EXPERIMENTS.

Corrosive sublimate (also known as mercuric chloride, $HgCl_2$).—Some time ago one of the Horticultural Commissioners of San Bernardino County remarked to me that he had used a simple solution of corrosive sublimate for the purpose of destroying various kinds of scale insects on nursery trees, and had obtained very good results by the use of the same; and it was also reported in some of the San Diego papers that a gentleman living in that county had obtained better results by the use of a solution of the above kind than he had by using any other kind of insecticide for the destruction of the black scale.

Thinking the subject worthy of investigation, I made a few experiments with this substance, but the results were far from being satisfactory. I dissolved the sublimate in cold water by frequent stirring; this required about 15 minutes, and the solution was of a dark bluish-gray color. Following is a brief account of these experiments:

(224) Corrosive sublimate, 2¼ ounces; water 100 gallons. Sprayed on an orange tree infested with the red scale at 3 p. m., October 10, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(223) Corrosive sublimate, 4½ ounces; water, 100 gallons. Sprayed on an orange tree at 2:30 p. m., October 10, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(236) Corrosive sublimate, 1⅛ pounds; water, 100 gallons. Sprayed on a dormant pear tree infested with the San José scale at 10 a. m., December 31, sun shining, light breeze. February 3, found a great many living San José scales on this tree.

The price in this city of the corrosive sublimate in 10-pound lots is at the rate of $1.40 per pound; at this rate the strongest solution I used (experiment 236) would cost about $1.63 per 100 gallons. I did not test a stronger solution than this, since its cost alone would prevent its being extensively used.

Glue.—For the purpose of testing this substance as an insecticide for the destruction of the red scale on citrus trees I made a few experiments with it, but with very unsatisfactory results. The grade I used is of a light brown color, not the white, nor yet the poorest grade, but such as is used by cabinet-makers. To dissolve the glue I simply boiled it in water, and it dissolved in about 10 minutes. Following is a brief account of these experiments:

(227) Glue, 4½ pounds; water 100 gallons. Sprayed on an orange tree infested with the red scale at 4:30 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(226) Glue, 8.1 pounds; water 100 gallons. Sprayed on an orange tree at 4 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

(225) Glue 12½ pounds; water 100 gallons. Sprayed on an orange tree at 3:30 p. m., October 11, sun shining, light breeze. November 13, leaves and fruit uninjured; found great many living red scales on this tree.

In this city (Los Angeles) the price of glue of the above grade in 10-pound lots is at the rate of 50 cents per pound; at this rate the strongest solution I used (experiment 225) will cost $6.25 per 100 gallons. This, of course, is much too expensive for ordinary use as an insecticide, and for this reason I did not test a stronger solution.

ALOES.—Dr. M. F. Bishop, of Alameda, the owner of a large orchard of deciduous fruit trees in the vicinity of San José, in the northern part of the State, gave me a package of aloes, with the request to test it on the scale insects infesting citrus trees. Accordingly I made a few tests with it, simply dissolving the aloes in cold water, straining the solution through a piece of Swiss muslin, and then spraying it upon the tree. The aloes is not readily soluble in cold water, and 4 days were required for it to dissolve, being occasionally stirred during this time. The experiments are as follows:

(243) Aloes, 12½ pounds; water, 100 gallons. Sprayed on an orange tree infested with the yellow scale (*Aspidiotus citrinus*) at 10:30 a. m., March 22, sun shining, light breeze. April 23, leaves and fruit uninjured; found many living yellow scales on this tree.

(242) Aloes, 25 pounds; water, 100 gallons. Sprayed on an orange tree at 10 a. m., March 22, sun shining, light breeze. April 23, leaves and fruit uninjured; found several living yellow scales both on the leaves and fruit of this tree.

The price of the aloes in large quantities is at the rate of 16 cents per pound; at this rate the strongest solution I used (experiment 242) would cost $4 per 100 gallons. At this strength (25 pounds of aloes to 100 gallons water) it proved fatal to a large percentage of the scale insects, and doubtless if it had been used one-half stronger it would have been entirely effectual; but the high price of a solution of the latter strength would prevent its being used on a large scale.

REPORT OF EXPERIMENTS WITH RESIN COMPOUNDS ON PHYLLOXERA, AND GENERAL NOTES ON CALIFORNIA INSECTS.

By ALBERT KOEBELE.

LETTER OF SUBMITTAL.

ALAMEDA, CAL., *October* 20, 1890.

SIR: I herewith submit report upon experiments, chiefly with resin compounds, on *Phylloxera vastatrix*, and observations made during the year.

Very respectfully,

ALBERT KOEBELE,
Field Agent.

Prof. C. V. RILEY,
U. S. Entomologist.

By your direction a series of experiments was carried on, chiefly with resin compounds, upon the *Phylloxera* in Sonoma Valley during September and the beginning of October.

In preparing the compounds the following were used: Bicarbonate of soda, sal soda, and Greenbank's caustic soda, 98 per cent. Three pounds are required of the former to dissolve 4 pounds of resin properly, or, in other words, to make a resin soap; 1 pound of the latter is sufficient to dissolve 10 pounds of resin or even 11, but I did not succeed in dissolving 12 pounds, as parts of the resin would always remain. In repeated and careful trials this could not be overcome.

The results showed somewhat in favor of the bicarbonate of soda as far as to destruction of the insects, but the price has to be considered. Next to this seems to be the emulsion prepared with caustic soda, but it is a difficult matter to decide which will work best without carrying on an extensive series of trials. It is safe to say, however, that the results will not vary greatly.

One pound of resin was used to each 10 pints of compound, and this again was diluted with water at a strength of 1 pound of resin in 2½ gallons of water, up to 1 pound in 37½ gallons of water—one part of compound in thirty parts of water. This compound will, as has been previously stated, do effective work on unprotected Aphids, *i. e.*, such as are not covered with cottony or mealy exudations, at one part in

fifteen parts of water, or 1 pound of resin in about 16 gallons of water. (The former mixtures were somewhat stronger; 1 pound of resin in 9 pints of liquid.) The action upon the Phylloxera is much more marked and with a mixture of one part of compound in thirty parts of water the insects, if immersed for a few seconds only and left exposed, will die, notwithstanding this solution will not adhere to parts of the roots, not having at this strength the required penetrating power which a sufficiently strong solution, say about 1 pound resin in 15 gallons of water, has, and more so than any other insecticide I know of. The experiments were made on 25-year-old Tokay vines (the only ones remaining that have withstood the ravages of the Phylloxera), in loamy soil, which was completely dry and hard at this time of the year, no moisture being noticeable until a depth of from 10 to 12 inches below the surface was reached.

In all cases the ground was removed to a depth of about 6 inches, forming a hole 4 feet in diameter. Ten gallons of the solution, it was observed, penetrated here to 12 inches in depth around the roots where the hole was deepest, or about 18 inches from original surface of ground, and most of the insects were destroyed to about 16 inches in depth, if the 10 gallons contained 4 pints of compound. In the later experiments these holes were made only about 2 feet in diameter, and nearly if not the same results were obtained with only half the amount or 5 gallons of the mixture. This is more practical, as the chief roots only are reached and the solution can be used so much stronger. The less solution required the better, providing it will do the work, for at 10 gallons to each plant this would mean 7,000 gallons or over per acre. If the solution is applied at another time of the year, say early spring, when rain is still expected, the results undoubtedly will be still more favorable. I have had excellent results with solutions prepared with caustic soda by using 4 pints of this to 16 pints of water only and applying 5 gallons of water soon after and 5 gallons the following day. This destroyed the Phylloxera to nearly the depth the fluid reached. Thus it will be seen if a small amount of the mixture, sufficiently strong, be applied in early spring the following rains will do the rest. As it was, with the dry soil, the 4 pints of compound in 10 gallons of diluent did better work than the same amount of compound in only 5 gallons, for the simple reason that it penetrated farther and thus reached more of the insects in sufficient strength to kill. It must also be remembered that a completely dry soil will take up a large amount of the l.quid, whereas in a moist soil this is not the case.

The compounds were prepared as formerly, sal soda 3 pounds, resin 4 pounds, dissolved together with 1 quart of water, and water added slowly while boiling to make 40 pints. The caustic soda, which comes in 10-pound tin cans, is dissolved in 4 gallons of water, after which 4 gallons more should be added. This lye will dissolve 100 pounds of resin and make 125 gallons of compound, sufficient for 250 plants, and

costing at wholesale in San Francisco (T. W. Jackson & Co., No. 104 Market street) $2.50. This is sufficiently strong, and to use more is unnecessary, as it was found that even 3 pints of the emulsion to the plant would do the work.

I will give here a receipt for preparing the cheapest compound. This is with common caustic soda, such as is sold at wholesale at about 5 cents per pound:

Caustic soda, 77 per cent	pounds	5
Resin	do	40
Water to make	gallons	50

First the soda should be dissolved over fire with 4 gallons of water, then the resin added and dissolved properly, after which the required water can be given slowly while boiling to make the 50 gallons of compound. This will make 500 gallons of the diluent, sufficient for 100 plants, and costing about 84 cents.

While a much weaker solution would kill the Phylloxera, this is recommended, as it also destroys their eggs effectively. Below are given the results of some of the experiments to show the effects of various strengths. Most of these have been duplicated or tried upon several plants. A small mite (*Tyroglyphus* sp.), always very abundant among the Phylloxera, and, as a rule, feeding upon the sap of the roots, yet from numerous empty skins appearing to feed also upon the lice, was in no case injured by these resin washes.

COMPOUND NO. 1.—*Bicarbonate of soda*, 3 *pounds* ; *resin*, 4 *pounds*, *and water to make* 40 *pints*, *costing* 15 *cents*.

Compound, 1 gallon; water, 6 gallons; in holes 4 feet in diameter. Destroyed insects to about 12 inches in depth from original surface, as well as the eggs of the same, which became dark in color.

Compound, one-half gallon; water, 4 gallons. Destroyed all insects where they were reached (occasionally a living one running about).

Compound, 1 part; water, 10 parts; about 10 gallons of the fluid used. This will destroy all lice and their eggs completely to 12 inches from original surface, but not deeper.

Compound, 1 part; water, 12 parts; 9¾ gallons used. Twenty-four hours after application some of the solution remained still on top, and on examining 6 days later it was found that it had penetrated the ground to 12 inches from original surface. Much of the solution had evaporated and left a brown scum (dry soap) on top. It will also destroy most, if not all, of the eggs.

Compound, 1 part; water, 14 parts. Three and three-fourths gallons of the diluent in holes 2 feet in diameter killed the insects to 8 inches in depth, or 14 inches from original surface.

Compound, 1 part; water, 16 parts; 8½ gallons diluent. Occasionally a living insect found and large numbers of mites on the nearly dead vines.

Compound, 1 part; water, 18 parts; 9½ gallons diluent; examined 5 days after. Nearly all the insects dead to 14 inches in depth, but most of the eggs looked bright yellow and no doubt will hatch. Behind the thick bark near the top, where apparently the solution did not penetrate, a number of young lice were found alive.

Compound, 1 part; water, 20 parts; 10½ gallons diluent; in holes 4 feet in diameter. An examination 5 days later showed the fluid had penetrated the ground on plants 15½ or 20 inches from original surface. All the insects were destroyed 13 inches in depth and but very few living 3 inches deeper. This solution seems to work best of all this series, but it is doubtful if the eggs will be affected by it.

COMPOUND NO. 2.—*Caustic soda*, 98 *per cent.*, 1 *pound; resin*, 10 *pounds*; *water to make* 12½ *gallons*; *compound costing* 25 *cents.*

Compound, 4 pints; water, 4 pints; in hole 4 feet in diameter; 5 gallons of water added 1 hour later and the same quantity next day. Very few dead insects were found upon this plant, and none living. Not sufficient to show proper result.

Compound, 4 pints; water, 2 gallons; 5 gallons of water added 1 hour after and 5 gallons the following day. Examined plants 7 days later; result very satisfactory, hardly any living phylloxera as far as the fluid reached. After examination 5 gallons more water were added and again examined a week later, when no living insects could be found to a depth of 18 inches.

Compound, 4 pints; water, 10 gallons. Destroyed insects to about 8 inches in depth and but few below this.

Holes only 2 feet in diameter; 5 gallons of water in same first, and solution 1 hour later in the four succeeding experiments.

Compound, 4 pints; water, 4½ gallons; examined 13 days later. Destroyed insects and eggs as well, which had become very dark. Occasionally a live specimen running about.

Compound, 3 pints; water, 4½ gallons. Examined 13 days later and found all insects dead that had been reached.

Compound, 2½ pints; water, 37½ pints. Examined 13 days later. A piece of root about 10 inches deep one-half inch in diameter by 6 inches long and completely covered with phylloxera showed but one single living young, probably hatched from egg after application.

Compound, 2 pints; water, 4½ gallons; also examined at the end of 13 days. All insects to 8 inches below ground or 14 inches below original surface were destroyed, as well as a large part of the eggs. Occasionally a living young was found wandering about.

Four other experiments were made with this compound, using 1, 2, 3, and 4 pints in 20 of the solution, the ground having 4 hours previously been saturated with 5 gallons of water in each case. Examined 12 days after; results were not good with 1 pint but were progressively better with the other three. Applied 4 gallons more water on plants where 3

and 4 pints had been used, and found 2 days later that this additional water still increased the effect.

In addition to this a number of plants were treated with this compound to note the results next spring. The holes were made 2 feet in diameter, and after the solution had disappeared the wet ground from the outside was placed around the plant and the hole closed again. The experiments were: Five pints of compound in 5 gallons of the solution, four plants; 4 pints of compound in 5 gallons of the solution, eight plants; 3 pints of compound in 5 gallons of the solution, ten plants; and 2 pints of compound in 5 gallons of the solution, ten plants.

COMPOUND NO. 3.—*Caustic soda*, 98 *per cent*, 1 *pound; resin*, 8 *pounds; and water to make* 10 *gallons of compound, costing* 22 *cents.*

Compound, 4 pints; water, 7½ gallons. Examined 6 days later; result good.

Compound, 4 pints; water, 10 gallons. Examined 6 days later and found result favorable.

Compound, 3 pints; water, 75 pints. Found only part of insects destroyed 6 days later.

Compound, 3 pints; water, 90 pints. There were not enough insects upon this plant to deduce fair results, which would no doubt be very poor.

COMPOUND NO. 4.—*Sal soda*, 3 *pounds; resin*, 4 *pounds; and water to make* 5 *gallons of compound; costing* 11 *cents.*

Compound, 4 pints; water, 7½ gallons. Examined 5 days later and found all insects killed except a few living on a plant under thick bark, where solution apparently did not penetrate.

Compound, 4 pints; water, 10 gallons. Examined 5 days later and found insects dead to 12 inches in depth from original surface, with only occasionally a live one walking about.

Compound, 3 pints; water, 75 pints. On examining, 5 days later, only the insects near surface were found dead.

Compound, 4 pints; water, 15 gallons. This destroyed only partly the lice near the top.

The following four experiments were made with this compound, the ground having been previously soaked with 4 gallons of water:

Compound, 3 pints; water, 21 pints. Examined 12 days later. Did not show good results, as part of the insects were found alive. Twice the amount of water with the same quantity of compound will do much better work.

Compound, 3 pints; water, 33 pints. Examined 12 days later and found results fairly good. Only a few living ones were running about.

Compound, 2 pints; water, 30 pints. On examination numerous live insects were found, but more than half were killed.

Compound, 2 pints; water 38 pints. Result about the same as in preceding experiment.

These four experiments were repeated and the water added (3 gallons) 2 hours after instead of before application of emulsion. The results in this case were much more satisfactory, destroying most of the eggs in the two first experiments and nearly all of the phylloxera in the two last to a depth of about 10 inches.

GENERAL NOTES.

It was probably owing to the unusually heavy rainfall during last winter that insects were comparatively scarce in the early part of the season. At least no complaint was noticed or heard during this time. While a large number would undoubtedly be destroyed by weeks of excessive rains and floods, yet there are such as are not or only slightly affected by this element. I may cite here, for instance, such species the eggs of which are found upon trees and shrubs during the winter months as well as the eggs of locusts usually deposited on dry hillsides. On a visit to Sonoma county during May, the larvæ of *Clisiocampa* were extremely abundant. Two species were found, namely, *C. constricta* and *C. thoracica*. The first species predominated in numbers, and while usually feeding upon deciduous oaks was also found upon Live Oak and *Quercus agrifolia* as well as various shrubs. In confinement these larvæ were furnished with food consisting of leaves of Plum and Cherry, but for three days they would not feed upon these and readily attacked the leaves of Live Oak which were given them, and upon these they were raised. *C. thoracica*, which is the species defoliating various fruit trees, was found chiefly upon willows, but also upon oaks, and here again usually upon White Oak, upon which its eggs were found in October. This species was bred upon leaves of Prune and Cherry.

At the end of May of the present year, I received from Mr. F. L. Washburn, entomologist of the experiment station at Corvallis, Oregon, a few *Clisiocampa* larvæ new to me. He said they were found feeding upon a species of *Cratægus* and were sent with leaves of apple, upon which I reared them. On my visit to Washington these larvæ were met with at Tacoma, on June 8, within webs upon Alder (*Alnus rubra*), and again at Easton, during July, upon Willow. Near Tacoma I also found what I took to be the larvæ of *C. thoracica* very abundant upon *Cratægus*, Alder, Hazel, and various other shrubs. Two of the larvæ were taken to Easton, and one pupated and to my surprise produced not the expected *C. thoracica*, but *C. erosa* Stretch.

About 10 miles along the railroad in southern Oregon, about the beginning of June, larvæ and webs of one of these moths were seen in large quantities on dry hillsides upon *Purshia tridentata* DC., *Ceanothus* sp., and also Wild Cherry. While crossing the Columbia River on steamer, June 8, at which time the water was very high, large numbers of these larvæ were observed floating upon the swift current and as

many as a dozen could be seen at one time, but of all the hundreds seen very few were dead. They were usually in a half circle and completely dry above and were carried off to be distributed safely along the shores. In both cases I had no opportunity to obtain specimens for identification.

As to the parasites, so far two species of a small Chalcid were bred from 37 egg masses of *C. constricta* found within three hours while collecting Cynipid galls in Sonoma County during October. This species is preyed upon by Tachina flies, which are or have been, the present season, the chief agent in destroying them. From about two hundred grown larvæ collected but very few moths were obtained, the Tachina maggots issuing from the dying and spun-up larvæ in large numbers. No ground for their reception had been furnished in breeding cases and they pupated among the leaves and excrement. At least 80 per cent of these larvæ were parasitized and but one of the flies has issued up to date. I also obtained one large cocoon of an Ichneumonid from larvæ in confinement and others were still found in nature during September.

C. thoracica was also infested by Tachina larvæ, but only about 30 per cent. were destroyed by these maggots. Two species of the flies have come out so far. *C. californica* was noticed full of eggs of these flies and some had previously been bred. An Ichneumonid was obtained from young larvæ the present year. Professor Rivers, of Berkeley, informed me the end of April that he had previously observed one of these larvæ at Bay View upon Willow, and accordingly a trip was made to that locality and this species was found as well as its tents, not alone upon Willow, but also on the scrubby Live Oaks growing there, Hazel, Wild Currant, *Rhamnus californica*, Blackberry, and other plants, showing that this species is not confined to Live Oak alone.

No Tachina has yet been obtained from the species in Santa Cruz Mountains, nor have I observed any eggs, but larvæ of this species placed upon Cherry and Prune at Alameda were badly attacked. The same species of Ichneumonid bred from larvæ of *C. californica* has also been obtained from this. This species was observed upon Plum, Prune, Willow, *Ceanothus* and *Cercocarpus*.

Two species of Ichneumonids were bred from the new species of the north, one from larvæ found at Tacoma, and the second from those found at Easton.

I may mention one Noctuid larva as very destructive to buds, young fruit, and foliage of fruit trees, chiefly Apple, Pear, Plum, and Prune. This is *Tæniocampa*, and I have full proof that the destruction of a large share of the buds and young fruit, so universally, yet incorrectly, attributed to birds on this coast, is due to this larvæ. In the very early spring, often in February, these moths make their appearance from hibernated chrysalids and copulate, and the female deposits her

eggs, from two to three hundred or more, in crevices of bark. I found them in large numbers together, thrust deep into a place where one of the branches had broken off. The young larvæ soon made their appearance and in want of leaves began to feed upon buds and blossoms, and later on, as I have repeatedly observed on apple trees, upon the young fruit also. Within about 24 days these larvæ become full grown and enter the ground for pupation to remain in this state for nearly 11 months. If only one or two early broods occur upon a single ordinary tree, they will, in some cases, destroy most if not all the fruit buds before any leaves appear. The light green, white, variegated, and striped larvæ at rest on the under side of leaves during the daytime are not, especially by an untrained eye, very readily discovered, and hence are overlooked and the more innocent bird is made responsible for the damage done.

During April, 1888, when I had a brood of these larvæ in confinement at Alameda, a common titmouse, *Lophophanes inornatus* Gamb., was noticed flying constantly to an old apple tree and carrying off dozens of these very larvæ to a hollow tree not far distant, within which it had a nest with six young. These birds are quite plentiful at this time of the year and are the only enemy of this larva as yet observed. None of the numerous larvæ collected the present year appear to be parasitized.

By jarring the trees in the early morning these larvæ, especially the larger, will fall to the ground, and can readily be collected and destroyed. If the tree be only slightly shaken, all the mature larvæ will drop.

Caloptenus devastator, so well remembered since its outbreak in 1885, has again been on the increase the present season and is quite abundant in Sonoma County as well as around Alameda, where *Camnula pellucida* was equally as numerous. Aside from complaints in Sonoma County others were heard of in Yolo County. I quote from the Woodland Democrat of September 11, 1890:

> For the past few weeks our farmers have been watching their alfalfa crops very closely. The Army Worm and the Grasshopper are both here, although not in such quantities as in the early days. In some cases the crops in young vineyards have been entirely destroyed by them. C. Eakle lost all his grapes by the grasshoppers, and others have shared a like fate. In other cases the alfalfa crops have fared badly from the effects of the worm and the hopper. Mrs. P. Hannum had saved some alfalfa for seed, but the worm attacked it, and she was obliged to cut it for hay in order to save any of it. Mr. Hopkins, we understand, was caught in the same predicament, while the pastures of those who have lately irrigated and where the clover is just beginning to grow nice and green are full of the hoppers, and the worms have also attacked many others.

As yet no specimens from the above locality can be obtained, but it is more than likely that the injury was caused by several species and the Devastating Locust among them. One favorable season, however, should no parasites appear, would again show a marked increase in destructive numbers, and local outbreaks may be expected the coming summer.

ENTOMOLOGICAL NOTES FOR THE SEASON OF 1890.

By Mary E. Murtfeldt.

LETTER OF SUBMITTAL.

Kirkwood, St. Louis County, Mo.,
October 31, 1890.

Sir: Inclosed please find summary of my notes on injurious insects for the present year, as observed throughout the season in St. Louis County, and as compiled from correspondence with and occasional visits to other sections of the State. As in preceding years, many thanks are due you for various determinations and helpful suggestions.

Respectfully, yours,

Mary E. Murtfeldt.

Prof. C. V. Riley,
U. S. Entomologist.

GENERAL OBSERVATIONS.

The season of 1890 throughout the Mississippi Valley has been in many respects unusual. The winter months were characterized by a temperature much above the normal, by occasional very heavy rains, and, after the middle of January, by a prevalence of clouds and excessive moisture. Many shrubs, for example Forsythia, Cydonia, and Lilac bloomed in the open air about the holidays, while the buds of all fruit trees were much swollen, and peaches and apricots opened their blossoms in sheltered situations in February. During early March the mercury for the first time in the year dropped to the neighborhood of zero, and on the last day of the month occurred a phenomenal fall of snow. April also was cold and damp, and similar weather prevailed until the middle of May, the soil, except where drainage was exceptionally good, being in poor condition for planting. With the first of June excessive heat set in, and for seven consecutive weeks the mercury was seldom below 90° F. at midday, and usually approached or exceeded 100°. This extreme heat was accompanied by an equally severe drought for the same length of time, scarcely mitigated by two or three very slight and very local showers.

That the effects of such a season should be plainly marked on insect life is not surprising. The following memoranda show considerable deviation from the records of preceding years.

Chinch Bugs were not reported as injurious in any part of the State, and scarcely a specimen could be found during midsummer and early autumn.

Canker Worms.—Very few, and found mostly in orchards or on trees standing somewhat above the general level. The male moths were flying every month during winter, and an occasional female was also seen in January and February. Probably the severe cold of March destroyed a large proportion of the very young larvæ, more perhaps by retarding the development of the apple leaves than by the direct effects of the cold.

Of the few worms that were found later in the season taking their noonday siesta on the trunks and larger branches of the trees, quite a number were seen which had evidently been attacked by some Carabid or other predaceous species, the skin having been punctured and the fluids oozing out with every motion. All injured worms perished, but what the assailant was I was not able to discover.

Cutworms (*Agrotis* and *Hadena*).—Vegetable gardens in the spring enjoyed an immunity from these pests that was most welcome to the gardener. This was probably due to the fact that some of the most destructive species hibernate in the larva state, and the degree of cold not being sufficient to reduce them to complete dormancy they perished of starvation and dampness or fell victims to the birds, which remained with us in greater numbers than is usually the case. My memoranda show that very few Noctuid moths of any kind were taken at light previous to the middle of August. To this scarcity of Noctuid pests there were, however, two notable exceptions—that of *Gortyna nitela* and *Heliothis armigera*, which have seldom committed so great injuries to certain crops as during the present year. About the middle of June many samples of young corn and potato stalks were sent me that were being bored by the first-named larva, and it was then reported from some localities—among others from Kidder, Missouri—as having destroyed fully one-half the crop of potatoes. Its injuries to young corn were also extensive, but I have no data for making an estimate. It was also found in considerable numbers, when very small, in small grain. In this it could scarcely reach maturity, and probably migrated to the stalks of such more succulent plants as were conveniently near. In the case of the attack on potatoes a treatment with Paris green and flour was recommended, on the probability that in passing from one stalk to another the worm would obtain a sufficient quantity of the poison to destroy it. Of the success of this experiment, if tried, I have not been informed. It did not occur in any noticeable numbers in the vicinity of Kirkwood.

Heliothis armigera was very destructive on both early and late corn,

especially on the latter. In the southern part of the State it injured the tomato crop to a considerable extent. Spraying with Paris green and with other arsenical compounds was tried with considerable success previous to the ripening of the fruit, but there is considerable danger in its use and it is best to thoroughly drench the plants that have been treated with clear water a day or two after the use of the insecticide. Experiment on a limited scale shows that it can be kept from corn by the same remedies, but how far this would be practicable in the field has not yet been demonstrated.

The Striped Flea-beetles (*Phyllotreta vittata* and *P. sinuata*) did not appear at all on early Crucifers, nor have they been observed in any considerable numbers in this vicinity at any time during the growing season. Whether this notable riddance was due to atmospheric conditions or to the scarcity of the fostering weeds, *Lepidium* and *Arabis*, I am not able to decide.

The Corn Flea-beetle (*Chætocnema pulicaria*) was reported to me from various localities as unusually numerous and injurious. Mr. Falcon, of St. Clair County, feared that he should lose his first planting from its attacks, but from later accounts the plants recovered more rapidly than he had expected.

The Plum Curculio was much reduced in numbers during winter, and as there was in this section, and indeed throughout the State, an almost entire failure of stone fruit crops, with the exception of the sour cherries, which the insect rarely attacks, there was very little of the work of the latter observed. A small proportion of the few early peaches that set were punctured, but that the midsummer drought prevented the development of the larvæ was indicated by the fact that such late peaches as there were did not show a single one of the food punctures which commonly so disfigure them. On one tree which the previous year had suffered so much in this way that the fruit was absolutely worthless, was a single peach that reached perfection without one stroke from the beak of a curculio; and similar observations were made on other trees on which a very little fruit ripened. Nor was I able to find *Conotrachelus* breeding in apples, although during June and July I examined nearly six hundred specimens of fruit, a few of which showed punctures that might have been made for food. Should other conditions be favorable, I think, so far as this insect is concerned, we may predict for 1891 fine crops of stone fruits.

Plant lice, always quite abundant in the spring, amounted this year almost to a scourge. Trees, shrubs, and herbs alike suffered, and for many plants there was no after-recovery. The species causing the most appreciable loss was probably the Grain Aphis (*Siphonophora avenæ*). It occurred throughout the State on all small grain, even on rye, causing, undoubtedly, some shrinkage of that crop as well as of wheat, but its most disastrous attacks were on oats. About the middle of May farmers began to be alarmed for the safety of this crop, and subsequent

developments proved their fears to be well grounded. Letters of inquiry and packages of specimens came to me from all directions, and during a trip about the first of June, to Butler County, on the southern boundary of the State, I was able to observe for myself the dwarfed and sickly appearance of small grain everywhere along the railroad, attributable in all cases to the attacks of this insect. Shortly afterward the outfields in St. Louis County and in many other localities were plowed up and replanted to corn, which, owing to the drought and to its own insect enemies, was, in its turn, a poor crop. The unusual prevalence and unparalleled multiplication of *Aphididæ* was undoubtedly due to to the scarcity of their natural enemies, both parasitic and predaceous. It was not until the middle of June that the larvæ of *Syrphidæ*, *Coccinellidæ*, and *Chrysopa* became numerous, and, reënforced by parasites of the genera *Aphidius* and *Trioxys*, finally brought relief from the pests; too late, however, to prevent irreparable injury to many herbaceous crops, young fruit trees, and various sorts of shrubbery.

A somewhat remarkable development of the season was the appearance in unusual numbers of many insects not often accounted noxious, and the reappearance of some species not observed in this locality for many years.

Among the former may be mentioned the great abundance and variety of "stinging" larvæ, principally *Limacodes*. For the first time in my experience the beautiful larvæ of *Parasa chloris* were so abundant on some young apricot trees in the orchard of one of our neighbors as to do great damage to the foliage. When full grown, three-fourths or more of an inch in length, thick, oblong, sub-cylindrical, gaily striped longitudinally in carmine red, purple, and bright yellow, the stinging spines concealed in the two rows of deflected bright yellow plumes that adorn the back, gliding with slow, graceful motion over the leaves, they were almost too ornamental to doom to destruction. As they were very voracious, however, the latter was a necessity of the case. Those that were preserved were fed to maturity on the leaves of Chickasaw plum, to which they were transferred without difficulty.

Euclea querceti H. S., of the same form and size as *P. chloris*, but much less brilliantly colored, being of a dull, mottled green, with two or four dark purple-red spots on each side of the dorsum, and having the plumose spines pale green, appeared on Plum, Cherry, and Apple in the orchard, as well as on Sycamore, Post Oak, and Wild Cherry in the forest. It was not, however, in any destructive numbers on any fruit tree.

So far as coloration is concerned this larva varies greatly. The crimson sub-dorsal spots, usually quite large when there are but two, are in some examples smaller and less conspicuous and are followed posteriorly by a second pair. The longitudinal ridges on which these are situated, and from which also proceed the larger urticating spines, vary in hue from pale pea green to yellow and bright orange. A second

variety was so distinct as to be described, previous to breeding, as another species. This is entirely of a pearly, translucent white color, with fine, wavy, purple lines, one on each side of medio-dorsal space and two others lower down on each side inclosing the second row of spines, which, like the general surface, are translucent white. There is a large purple spot a little back of the middle on each side of the dorsum. I have found this variety only on pear, and it is rather rare. The cocoon is spun among the leaves and does not differ in color, form, or texture from those of other *Limacodes.* The moth bred from this pale larva does not differ from those of typical *querceti*, being of a rich fustic brown, with bright green and velvety black ornamentation. In the size of the green and black spots and in general intensity of color a series of moths of this species also exhibit considerable variation.

The almost equally beautiful and even more strikingly marked Saddle-back Caterpillar (*Empretia stimulea*) occurred in very unusual numbers on Plum, Pear, Chestnut, Maple, and Wisteria vine, doing considerable damage—especially during the semi-gregarious period, which continues to the third molt—to the foliage of the fruit trees attacked.

Phobetron pithecium and *Limacodes scapha* were other species of this group observed.

Lagoa crispata was quite numerous on White Oak and Chestnut, and colonies of *Saturnia io* appeared on Corn and Sassafras and defoliated several rose bushes in our garden before we discovered the authors of the mischief. Altogether there was quite an array of "urticators," and gloves were very necessary to preserve the hands of the collector in taking them and also in caring for them in the rearing cage. They seem to dispense stinging points all over the foliage over which they crawl and all about the cage in which they are confined. I have often had my hands smart for hours after changing the leaves and cleaning the cage in which these larvæ had been reared, long after they were inclosed in their cocoons.

There was throughout this and contiguous States a notable outbreak of *Datana* both *D. angusii* and *D. ministra*, but especially the former. This species appeared on the Walnut in June, and the second brood again in August, and from the excessive and repeated defoliations it is probable that many fine trees have been destroyed.

During a journey taken about the 1st of September, numbers of trees were noticed bearing what would have been a heavy crop of nuts, but absolutely leafless, while the trunks were almost covered with larval exuviæ. The nuts were, of course, small and imperfect, the shrunken husks clinging to the seed. Several collections of the walnut-feeding larvæ were sent me, but not having a supply of walnut leaves convenient, I was not able to rear any of them, as they refused to accept as a substitute the leaves of hickory or of *Rhus glabra* or *copalina*, although some years ago I bred them from the latter.

During September the black-necked larvæ of what I suppose will

prove to be *D. ministra*, Drury, appeared on post oaks in Kirkwood and vicinity, defoliating portions of the trees infested. From their gregarious habit and their susceptibility to poison they were easily routed. Even a stream of water turned upon them from the spraying pump would dislodge and bring them to the ground, where they were easily killed.

Orgyia leucostigma, a species formerly abundant in this locality, but which I had not observed for ten or twelve years, was found on Sycamore (*Platanus*), on which, strange to say, it would not feed after the second molt, and consequently all caterpillars left on the tree perished before attaining half their growth. The question suggested by this observation was how the young larvæ came to be upon this tree which so evidently did not suit them for food. I could not find either cocoon or egg mass of the mother insect, nor were any of the larvæ discovered in the adjacent orchard.

Ichthyura inclusa, another species not observed here for many years, appeared on willows in great numbers in September, but coming so late in the season the defoliations did no serious damage.

In concluding these notes I wish to mention an insect that will probably prove most efficient in ridding the country of the pest of the Web Worm (*Hyphantria cunea*). This is the larva of a small and inconspicuous Carabid of the genus *Plochionus*, bearing the appropriate specific name *timidus*. I had observed during the month of June that the greater number of the webs of the caterpillar were unusually small and incomplete and seemed to have been deserted much sooner than usual.

Before I had time to investigate the matter, I received from Mr. J. C. Duffey, horticulturist at the Shaw Botanical Garden, a colony of the worms, interspersed among which were numerous small active Carabid larvæ, which Mr. Duffey informed me were preying upon the former. The collection was placed in a cage and arranged for convenient observation, and I very shortly had ocular demonstration of the correctness of Mr. Duffey's assertion. Many interesting observations were made upon these small but ferocious larvæ before they changed to pupæ, and the appearance of the perfect insect was awaited with much interest. The first beetle developed about the middle of July and proved to be the species named.

Comparatively few webs of the second brood of *Hyphantria* were seen in and around Kirkwood in August, and extensive examination revealed the fact that fully three-fourths of these also contained larvæ of *Plochionus*, which were busily engaged in reducing the numbers of the rightful inhabitants. Nor is the beetle confined in its diet to the web worm. I found the larvæ repeatedly during the present autumn in the masses of leaves webbed together by the somewhat gregarious larvæ of a Tortrix (*Cacœcia fervidana*) and between the two leaves webbed by various Tineids, especially *Cryptolechia nubeculosa* and *C. schlegerella*. (I doubt not I may have occasion to deprecate its work in the future

in these groups.) That this *Plochionus* had not appeared this season much to the east of St. Louis was evinced by the much webbed and defoliated orchard and forest trees noticed in Illinois and Indiana in August and September.

As Mr. Duffey proposes soon to publish a history of the insect, with detailed descriptions of its various stages, I defer offering my own notes upon its habits and forms until after the appearance of his paper.

A FEW MORE INJURIOUS MICROS ON APPLE.

A very considerable number of Microlepidoptera, including *Pyralidæ*, *Phycitidæ*, *Tortricidæ*, and *Tineidæ*, have already been characterized and catalogued among the more or less injurious insects of the orchard and garden; but the observations of almost every year add to this list, and I propose here to briefly describe a few which have not as yet been placed on the roll, but which in this locality are annually so numerous as to commit appreciable injury.

PENTHINA CHIONOSEMA, Zell.—The larvæ of this beautiful species were, last year, uncommonly abundant during the month of May on the leaves of apple, particularly in young orchards. They fold the leaves at the midrib, or sometimes one edge over to the midrib, fastening the edges all around firmly and feeding upon the inclosed upper surface.

Larva.—The larva is not especially characteristic, being of a pale opaque green color, without maculation, except the rather inconspicuous glassy piliferous plates. Head pale yellow, tinged with green, legs similarly colored; length from 16 to 17^{mm}; diameter, 3^{mm}. Form subcylindrical, tapering but slightly either way from middle.

When full grown it incloses itself under a rolled edge of the leaf, lining and strengthening the tube thus formed with a white silken web. The moth appears early in June, and I have no record of a later brood, although there may be one.

The original description, by Professor Zeller, is not accessible to me at present, but it will suffice to note the following characters:

Palpi and tuft of the head rich ferruginous, antennæ scarcely half the length of the wing, fine, gray brown. Thoracic tuft dark brown. Wing expanse from 15 to 16 ^{mm}—rather more than a half-inch. Ground color of primaries somewhat mottled dark brown, with a slight suffusion of olive, diversified by three broad, indistinct, irregular, obliquely transverse bands of purplish gray, having a somewhat metallic reflection; these transverse bands broaden toward the inner margin, where they almost coalesce. On the costal edge is a large, milk-white, rounded triangular or nearly semicircular patch, extending along the costa from the middle third, inclusive, almost to the apex, constituting a most distinguishing and ornamental character. Cilia purplish gray. Secondaries, silky, pale brown with lighter fringes. Abdomen and legs pale brown. Under side of wings pale, rosy brown, the large costal spots on this side inclining to orange.

PROTEOPTERYX SPOLIANA Clem.—The larva folds and webs into clusters the young leaves of apple during the month of May, appearing, preferably, on the shoots of small trees.

Larva.—When full grown it measures 10^{mm} in length by $2\frac{1}{4}^{mm}$ in diameter, the form being rather thick cylindrical; color translucent white, tinged with yellowish green; surface velvety; piliferous plates small, glassy, giving rise to short, fine, light hairs. Head and cervical collar same color as general surface or a little deeper in shade, inclining to amber. The head is broad and flat, with red-brown trophi, and a very large dark brown spot on each side. Legs and prolegs same color as general surface.

When full grown it forms a tough, oval cocoon, thickly covered with particles of soil, on the surface of the ground, occasionally just beneath it. It is but single-brooded, and is very difficult to rear in confinement, as it must be kept through the heat of summer and the cold of winter, and if a little too damp it molds, while if moisture is withheld it dries up. From almost innumerable larvæ collected during several years I have only been successful in rearing two or three specimens, enough, however, to determine the species, and, as the moths are always abundant early in the spring on the trunks of orchard and forest trees, there need be no scarcity of specimens for the cabinet.

Adult.—The moth expands 15^{mm}, wings rather narrow. In color it closely simulates the bark of the trees on which it naturally rests. The vestiture of the head is brown interspersed with gray; palpi and antennæ cinereous; thorax and abdomen pale brown. Primaries brown, with a series of oblique double silvery streaks all along the costal edge, extending about one-fourth across the wing; a large silvery spot of irregular outline, inclosing a patch of dark brown, is situated near the outer edge of the wing, and a less distinct patch of silvery scales occurs on the inner edge near the middle, while a shading of the same color modifies the brown tint on other portions of the wing. Cilia pale brown and cinereous intermixed. Secondaries cinereous, shading on costal edge to pale brown; cilia dingy white. There is some variation in distinctness of the markings and depth of coloring.

STEGANOPTYCHA PYRICOLANA Riley MS.—This is somewhat similar to the above in coloring, but smaller and proportionally broader winged. This bores the shoots of the second growth of apple in August and September, occasionally on recently planted trees, inflicting serious damage. The larva spins scarcely any web, but bores downward through the terminal bud, entering the stem for from half an inch to an inch, sometimes blackening all the growing points of a young tree.

Larva.—When full grown it is 8^{mm} long by $1\frac{1}{4}^{mm}$ in diameter, slender, subcylindrical, tapering slightly in both directions from middle segments; surface smooth; incisions deep; color, pale cream yellow, somewhat translucent; the dorsal surface beautifully mottled with rose red. Piliferous warts and hairs only discernible with a lens. Ventral surface pale, slightly concave, and much wrinkled. Head elongate, cordate, pale brown, shading to dark brown on the middle of each lobe; trophi prominent, dark brown, with two or three long light hairs on each side. Supra-anal plate oblong, large, dark, smoky brown. Legs and prolegs rather unusually developed.

I failed to rear the first specimens collected, most of them wandering around in the jar until they died. Subsequently, by supplying them with bits of pith or bark in which to bore, I succeeded in getting three or four imagos between the last of September and the first of October.

The moth expands 10mm. The head, thorax, and abdomen are densely covered with long hair-like scales, of a dull gray-brown color with bluish reflections. Basal half of primaries of similar color, but with more intermingling of blue and brown scales. About the middle the wing is crossed by a broad, irregularly outlined band of rich brown, sparsely intermingled with silvery scales, and the terminal third is quite evenly mottled in brown and leaden gray, the costal edge of this portion being ornamented with alternate oblique light and dark streaks extending about one-fourth across the wing; cilia bluish gray; secondaries lustrous pale brown, shading to cinereous on costal edge; cilia dingy white.

Professor Fernald, to whom a specimen was shown, considers it identical with Clemens's *S. salicicolana*, which I believe breeds in willow galls, but Dr. Riley pronounces it distinct, and he has types of Clemens's species.

GELECHIA INTERMEDIELLA ? Chambers.—This pretty Tineid appears in its larval form on the tender leaves of apple early in May and again in September. It gnaws the parenchyma from the upper surface, giving the leaves a burned and eroded appearance.

Larva.—8mm in length when mature, slender, cylindrical, tapering slightly in both directions from middle; incisions deep, giving it a submoniliform appearance. General color bluish green, acquiring a purple hue at maturity, with faint longitudinal stripes of cream white. Head pale brown with a tinge of green, ornamented with cream-colored markings on each side and a row of graduated cream-colored dots down the middle of the face. First segment narrow, without perceptible shield. Thoracic legs long, whitish, proceeding from papillated projections on the ventral surface.

This larva covers the leaves with fine web, in which it moves with great agility, and in which it rests suspended, without touching the surface of the leaf, except when feeding. It is semigregarious and very irregular in its development, some clusters of the leaves showing very recently hatched young, while on other clusters they will be full grown. It pupates on surface of the leaf under a little round cover of dense web, similar to those under which some spiders protect their eggs. The moths emerge in about 3 weeks after pupation and hibernate in the perfect state.

Adult.—A beautiful species, expanding 12 or 13mm. Head and thorax dark gray, more or less suffused with crimson; palpi dark gray, annulated with rosy white or pale pink. Ground color of primaries leaden gray and rosy white; scales about evenly intermixed. Three very irregular and variable, often interrupted, bands of rich olive brown cross the wing, intermingled with some light golden brown or ochreous scales; near the base and center of the wing these form quite distinct patches. The apical third of the wing is margined with alternate dark brown and rosy patches; cilia gray. Secondaries cinereous, with paler cilia. This species is closely allied to both *roseosuffusella* Clem., and *rubensella* Cham., resembling in coloration the latter and in size the former. Mr. Chambers says of it: "Intermediate between *roseosuffusella* Clem., and *rubensella* Cham., with one or the other of which it has hitherto been confounded. The third joint of the palpi is longer and more acute than in *rubensella*, more like that of *roseosuffusella*, but the fore wings are much less roseate than in either of the two other species, frequently showing no tinge of the roseate hue. * * * As in *rubensella* (and sometimes in *roseosuffusella*), the first dark band does not cover the base of the wing. The second band is like that of *roseosuffusella*, but the third extends across the wing, the dorsal portion being, however, paler than the costal, and the costo-apical part of the wing is ochreo-fuscous.

This description, or rather these distinctions, of Mr. Chambers apply to some examples, while to others they do not. Many specimens are very roseate and richly colored, while a few appear almost plain black and dull white. The three species are best distinguished in the larva state, in which there are very decided differences. *G. roseosuffusella* feeds on Clover, *G. rubensella* on Oak, while the species under consideration, so far as my observations show, is confined to Apple. The larval characters are also very diverse in the three species.

EXPERIMENTS WITH INSECTICIDES.

During the great prevalence of *Aphididæ* in the spring I made much use of pyrethrum and of the X. O. dust. Of the value of the former as a remedy for these pests, except in the case of one or two species, I have no occasion to change the favorable opinions already repeatedly published. The X. O. dust was thoroughly tested on the following Aphids: *Aphis mali* and *Schizoneura lanigera* on Apple; *Aphis prunifolii* on Plum; *Siphonophora rosæ* on Rose; *Myzus persicæ* on Peach; *Aphis brassicæ* on Cabbage; *Aphis* sp.? on Cucumbers and Squash; *Siphonophora* sp.? on Lettuce; *S. cratægi* on Thorns; *S. rudbeckiæ* on Solidago; *Aphis ambrosiæ* on *Ambrosia trifida*, and *Aphis chrysanthemi?* on Chrysanthemum. With its effects on all of these I was well satisfied, although in some cases it took several dustings to thoroughly clear a plant. When applied with a powder bellows it causes the insects to drop to the ground at once, where they may be pressed into the soil with the foot or patted down with a trowel. The more delicate species succumb to a single thorough dusting and never recover from the effects of contact with the powder. This preparation will also destroy *Siphonophora avenæ*, but whether it could in any way be applied to a field of infested grain has not been demonstrated.

The Black Chrysànthemum Aphis is one of the greatest pests of the flower garden and gives much trouble to both amateurs and professional florists. It hibernates on the plant and attacks the stolons as soon as they appear in the spring, and unless great care is taken to eradicate it, it is more or less numerous on the plants throughout the summer, dwarfing and deforming them by its punctures and by the loss of sap which it appropriates. As soon as the buds are formed it seems to develop with four-fold fecundity and requires assiduous attention to keep in check. The Buhach or pyrethrum powder is utterly useless against this species, probably because the plant from which it is made is so close an ally of the Chrysanthemum. The X. O. dust, composed of creosote and tobacco, is the best remedy within my knowledge, killing the Aphis without the slightest injury to the plant. I have found it best to apply during the middle of the day when the dew is off. A few minutes after dusting the plants, I pass along the rows or among the pots, and give each branch a smart shake or a blast of air from the empty puff, and every Aphis that has not previously dropped is dis-

lodged, and "to make assurance doubly sure," it is stamped into the earth. On most of the insect foes of the plant lice the dust produced no disastrous effect, but the larvæ of Syrphidæ would, in some cases, not recover from the pungent coating.

Arsenites of ammonia.—This new preparation, for which F. J. Andres, 25 Pearl street, New York, is the agent, was sent to me for experiment, in accordance with directions from the entomologist of the Department of Agriculture. It did not reach me until about the 1st of June, too late for use on a number of insects. It is a clear solution of arsenic in aqua ammonia, and apparently does not differ much from a preparation of my own devising, as reported on two years ago, and with the effects of which on vegetation I was not entirely satisfied. The directions accompanying each of the gallon bottles, in which it is put up, are to use one tablespoonful of the liquid to a gallon of water.

June 7.—Weather clear and hot. Prepared a quantity of the fluid as directed and had it applied to the following plants: To potatoes, on which were a few *Doryphora* larvæ; to rose bushes, on which still lingered a few larvæ of *Selandria rosæ*, *Characlea angulata*, and *Amphipyra pyramidoides;* to cabbage, covered with full-grown and young larvæ of *Pieris rapæ;* to cucumbers and squash infested with *Diabrotica.* It was too late in the season to test it thoroughly on apple for the Codling Moth, and as there were scarcely any peaches or plums or curculios, its effect on the latter insect can not be reported upon. Portions of the trees as well as of cherry were sprayed to discover its effect upon the foliage.

June 9.—Made the rounds of all plants sprayed and noted results as follows:

Potato plants slightly scorched, edges of the leaves curled, larvæ of *Doryphora* mostly on the ground dead, beetles sickly.

Rose bushes uninjured, or very slightly burned where the leaves were very tender; all larvæ killed.

Cabbage uninjured; all *Pieris* and other larvæ killed. Cucumbers much injured, squash less so; striped beetles killed or vanished.

Peach and cherry foliage badly scorched, turned yellow. Plum and apple only slightly injured. Other experiments later in the season made with one tablespoonful of the poison to one and one-half gallons of water were not injurious to any except the most delicate foliage, while in most cases it sufficed to kill *Sphinx quinquemaculata* and *Heliothis armigera* on tomato, *Darapsa myron*, *Cidaria diversilineata*, *Psychomorpha epimenis*, and *Desmia maculalis* on grape, with but slight damage to the foliage. The fruit being "bagged" was not touched by it. *Empretia stimulea* on plum and pear and *Datana ministra* on oak also speedily died from eating leaves that had been dampened with it.

I do not consider these experiments conclusive, as with the heat and drought, vegetation was not by any means in a vigorous condition, and therefore more liable to injury from poisonous applications. It is a most convenient preparation and leaves no sediment to disfigure the

foliage, and will, I trust, be found, by more thorough experiment, efficient as an insecticide when used of a strength that will preclude injury to foliage.

Late in the summer a preparation of petroleum sludge with soap was sent me from the New York Chemical Works for trial, but there were very few insects at that time on which to test it, while its almost intolerable and persistent odor is really a serious objection to its use, especially in small gardens.

In making my experiments, I have used the Lewis Combination Force Pump and Syringe, and consider them well adapted for use in small orchards and vineyards, and especially adapted for purposes of experimentation, where the larger and heavier appliances are not necessary.

REPORT ON WORK OF THE SEASON.

By Herbert Osborn.

LETTER OF SUBMITTAL.

Ames, Iowa, *October*, 1890.

Sir: I transmit herewith a report upon the work of the season, including mention of certain insects that have been observed during the season and notes regarding certain others, observations on which are in progress, with the expectation of giving more detailed accounts of their life histories and habits.

There is much yet to be done on the insects affecting grass before anything like a full report can be made upon them, but I shall hope to bring the work of the present season into shape for submission at the end of the year.

The work on the parasites of domestic animals has been continued and a part is already submitted for printing, while a considerable amount of other matter is in form to be presented at an early date.

Very respectfully,

Herbert Osborn.

Prof. C. V. Riley,
U. S. Entomologist.

During the past summer there has been no great depredation by any single insect pest in the State, but a number of the common species of insects have been working with their accustomed energy, and the losses from this source in the State have probably been up to the average of ordinary seasons.

The observations on insects affecting grass crops have been continued, and I am only the more strongly impressed with the importance of the insects affecting these crops in this State, and believe that the estimates given in my last year's report as to the probable loss from this source to have been by no means overstated.

Judging by the reports of the correspondents of the Iowa Weather and Crop Service, who represent every section of the State, the insects that have caused most extensive injury are those infesting meadows and pastures and sod land planted to corn. Not only are there numerous reports of injury by insects to timothy, to pastures, and to corn planted on land previously in grass, but numerous mention of poor condition in meadows and pastures, shortage in grass and hay crop,

etc., which, to any one familiar with the great number of insects now infesting grass land in this region, tell a certain story as to at least one of the great sources of loss.

Frequent mention is made of the Cutworms, Grubworms, Wireworms, etc., and it is evident that a very great variety of species are included in this list; but while I am certain that many species of Cutworms belonging to the common species of Noctuidæ are included in this list, I believe that much of this injury is due to the species of Crambus treated in detail in my report for 1887, the Dried Crambus (*Crambus exsiccatus*), or as called in the larval stage, the Sodworm or Turf Webworm. This has been very plentiful here in the adult form the present season, though by no means so abundant as in 1887, and I have no doubt that it has been as abundant in other parts of the State. The work of this species in meadows, however, would not be readily distinguished from that of Cutworms by those unfamiliar with the habits of insects, and even in corn the effect on the plants is not easily to be distinguished from the effects of Cutworms, Wireworms, or other forms of insects attacking the stalks at or near the surface of the ground.

LEAF HOPPERS IN GRASS.

In my report of last season I mentioned a number of species of leaf hoppers (*Jassidæ*) that are destructive in grass land. Further observation and collection in this same line has served to strengthen my opinion as to the great amount of injury to be attributed to these minute insects. A number of species particularly of the genus *Deltocephalus* occur in immense numbers in grass land, and among the most common of those observed here are the *Deltocephalus* (*Jassus*) *inimicus* Say, treated of in last year's report, but associated with these are *D. debilis* Uhler., *D. Sayi* Fitch, *D. Melsheimeri* Fitch, and a number of species apparently as yet undescribed. A fuller report upon these I hope to make a little later when material on hand can be more fully examined and a more complete statement of results given, but it may be in place to mention as one of the results of this study that I have been convinced that these insects are a very important factor in the production of "silver-top" in grass, this being one of the effects produced by their suction of the juices of the plant and resulting when they penetrate the succulent portion of the stem at the base of the terminal node. That other insects may and do cause this same form of withering and injury to grass I do not deny, but in a great number of examinations of injured stems I have in the great majority of cases found no insect within the sheath of the injured part, and feel positive that for these the injury could not have been produced by Thrips or Meromyza or any insect working within the stem while the presence of immense numbers of the leaf hopper on the affected plants and the presence of punctures show clearly the possibility of the injury being due to them.

This question has been more fully discussed in a paper read with your consent before the Association for the Promotion of Agricultural Science at the Indianapolis meeting. In that paper I have referred to different explanations for the silver-topped condition of grass and presented the grounds for my own opinion that for this locality and in blue grass the injury must be referred mainly to these Jassidæ. From the fact that these Jassidæ are exposed to the application of remedies that would not affect insects protected in the sheath it is evident that the adoption of measures to destroy these, as suggested in my last year's report, should result in a decrease of the "silver-top."

GRASSHOPPERS AND CRICKETS IN GRASS.

The common species of grasshoppers or locusts have been as usual very plentiful, *Melanoplus femur-rubrum* probably heading the list for abundance, but several other species, as *M. differentialis*, *Dissosteira carolina*, *Tomonotus sulphureus*, and *Arphia sordida* form a very conspicuous part of the grass-eating species. For the present season also there has been a very great abundance of the little field cricket, *Nemobius vittatus*. This was noticed as especially abundant on sunny hillsides in pastures and in many places aggregated in such numbers as to completely cover the surface of the ground. While this species has been rather frequently mentioned among the species common throughout the country and its herbivorous habits accepted, so far as I know by all, there has been apparently little attention to it as a destructive species or one worthy of particular attention on account of the injury it may cause in pastures.

It is quite evident, however, that when occurring in anything like the abundance in which it has been observed here this season it must be the cause of no little loss, and it may very well be associated with the more frequently mentioned locusts in the category of destructive meadow insects.

MISCELLANEOUS NOTES.

The Apple Leaf Skeletonizer (*Pempelia hammondii*) has been sent me this season from near Des Moines, where it was reported as doing considerable damage. This insect has been comparatively rare in the State for a number of years, but from the account received of its appearance this year it must have been in such numbers as to cause no little damage, and it is to be hoped that prompt measures will be adopted by the fruit-growers of that locality to prevent its spread.

The Turnus Butterfly (*Papilio turnus*) has been noticed as more than ordinarily abundant, the larvæ occurring in considerable numbers on various trees, especially on plum trees in this vicinity. While the species has seldom assumed an economic importance, in this State at least, it may be that it will require occasional attention, and it will of course readily succumb to the treatment by spraying, so efficacious for leaf-eating larvæ.

The Cherry Slug (*Selandria cerasi*) has also been quite plentiful and damaging cherry and plum trees. It would appear that this insect has been rather more than usually common in a considerable territory the present season, as I have heard of it from various localities. It is generally the case, however, that it does little damage for more than one or two seasons in succession, so that it seems hardly necessary to take any great amount of trouble in dealing with it unless it is working destructively upon particular trees, when the usual poisonous sprays suffice to rid the trees of its presence.

The Handmaid Moth (*Datana ministra*) has been on the increase apparently for a number of years past and for the last two years has succeeded in defoliating quite a number of trees in the vicinity, especially hickories and black walnuts. As mentioned in another place, the arsenite of ammonia was used in treating it this fall and proved very efficient in destroying the insects. Previously, we have used London purple for this purpose, and there is apparently little choice, unless there be sufficient difference in price to render one cheaper than the other. It is important in using any of the poisonous solutions for this species to spray the whole tree or as much of it as possible, since when only the part where the worms may be working at any particular time is sprayed, they are very likely in their next move to occupy some part where there is no poison to affect them, and they may in this way escape until they have caused considerable damage to the tree.

Abbot's White Pine Worm (*Lophyrus abbotii*) has appeared in the State, and so far as I am aware it is the first time that this destructive insect has been brought to notice in Iowa. It was sent to me from Farley and with the report that the evergreen trees were suffering severely from its attacks.

The Corn Root Worm (*Diabrotica longicornis*) is evidently on the increase and gradually extending throughout such localities as it has not hitherto occupied. Here, it appears very abundantly in the adult stage, and in fall, collecting in great numbers on flowers. So far as I know there has not as yet been any very great injury to the corn in the vicinity, but probably the worms occur in considerable numbers scattered through the various fields, and it is probable that in a short time they will multiply to such an extent that in fields kept long in corn they will cause serious loss.

The species of *Diabrotica* infesting squashes, melons, etc., *D. vittata* and 12-*punctata*, have been very abundant the past season, though perhaps not more so than is common for them, but the crops they infest have required attention in order to prevent serious loss.

The Potato Stalk Weevil (*Trichobaris trinotatus*) was observed this season for the first time and occurred in such numbers as to cause considerable damage. It was first noticed by Mr. F. A. Sirrine, a special student in entomology, at present assisting in the botanical work in the Experiment Station. It is quite likely that the insect has been present

in previous seasons in small numbers, but it has not been taken even in the adult form, in this locality till this summer, so that it seems more likely that it has been introduced in some way quite recently.

TESTS OF ARSENITE OF AMMONIA.

During the month of May I received instructions from Mr. Howard to make tests of an insecticide put on the market by Fr. Jac. Andres, of 25 Pearl street, New York, under the name of arsenite of ammonia, as agent for the Caspar Schneider Chemical Works. In due time the samples came from the New York firm and I proceeded to make such tests as were possible to determine both the effects upon various kinds of plants and its effectiveness in killing insects.

On the morning of May 30, 1890, between 9 and 10 o'clock of a hot, sunny day, I sprayed the following plants with a view to giving a thorough test of the effect on foliage:

Squash vines infested with *Diabrotica vittata.*

Cucumber vines infested with *Diabrotica vittata.*

Potato vines infested with *Epitrix cucumeris.*

Plum, Cherry, Box-elder, Willow, Elæagnus, Elm, Mountain Ash, Birch, Apple, Raspberry, beans, grass, and clover.

The results were watched closely for a number of days but the record of June 2 gives the results for the entire set. On that day a careful examination was made of all the plants that had been treated and it was found that in no case could there be found any injury to the foliage, except possibly a slight injury to the elm and the beans, but the injury was so slight, if any, in these cases that it could hardly be charged with certainty against the arsenite. The solution in this case was as given in the directions, a tablespoonful to an ordinary pailful of water, and the conclusion was that with this strength it could be applied without danger to any of the above-named plants.

On the squash vines and cucumber vines the beetles seemed much less abundant, but I was unable to find any dead insects around the vines. The hills treated, however, remained quite free from further trouble from these insects, while others in the vicinity were seriously affected. The failure to find dead beetles under the treated plants might easily result from the insects flying away after eating the poison to places of shelter and dying there. The same was true of the flea-beetle affecting potatoes. The beetles seemed much less abundant, but no dead ones could be found under the treated vines.

While it was so late in the season that it was not expected that this test would give any definite results as to the effect on the codling moth, it is worthy of mention that the branches of the apple tree sprayed with the arsenite were loaded with apples, while the other portions of the tree were much less fully loaded.

The apples also of this portion were quite free from worms, though in the late fall they were of course exposed to the action of the second

brood and a portion of the fruit was found infested. While this is not given as a good example of the effect of spraying, it seems strong enough certainly to warrant the conclusion that the arsenite of ammonia will prove as effectual as any other form of the poison against this pest.

There were none of the Colorado Potato Beetles to be found in the vicinity, so the poison could not be tested with them, a test that would have been of course more satisfactory, especially with the larvæ, because of the fact that the dead insects can afterward be found readily around the treated vines.

I was able, however, to give a thorough trial of the insecticide properties of the substance later in the season on the common Handmaid Moth (*Datana ministra*), which was very plentiful on some of the hickory and black walnut trees in the vicinity. A single application of the poison was found to kill the caterpillars in large numbers, evidently affecting all that fed upon the leaves that had been reached by the poison. Dead caterpillars began to be found in 24 hours from time of application, and for two or three days afterward the caterpillars were dying off rapidly. The application was in this case made a little stronger than in the first trials, and in a few days the trees showed some injury from the effects of the arsenite, so it seems quite evident that the strength for these trees must be kept within the limits indicated by the directions. The liquid is very convenient to mix with water, and forms probably a very uniform mixture, so that it seems to possess some points of superiority ver the arsenites in solid form.

REPORT ON SOME OF THE INSECTS AFFECTING CEREAL CROPS.

By F. M. WEBSTER.

LETTER OF SUBMITTAL.

LA FAYETTE, IND., *October* 22, 1890.

SIR: I herewith submit my annual report of observations on some of the insects affecting cereal grains. For assistance in carrying on the experiments connected with the studies of the Hessian Fly, I am greatly indebted to the following gentlemen: Hon. Samuel Hargrave, Princeton; Mr. W. S. Ratliff, Richmond; Mr. Miles Martin, Marshall; Hon. W. Banks, La Porte, and Hon. J. N. Lakta, Hawpatch; to Purdue University, and later the experiment station. I am also under obligations for use of land, seed, and labor in carrying out my own experiments here at La Fayette.

To yourself especially, and others of the division, I am under many obligations for the determination of specimens and other numberless favors.

Respectfully submitted.

F. M. WEBSTER.

Dr. C. V. RILEY,
U. S. Entomologist.

THE HESSIAN FLY.

Number and Development of Broods.

My experiments, notes, and observations upon this insect extend over a period of a little over six years, and while it received little more attention than was given other wheat-destroying species, a considerable number of facts have accumulated which, while not by any means clearing up all of the mysteries of the pest, will nevertheless serve to throw some light on several obscure points. Unless otherwise stated, all of my observations and experiments herein recorded relate to the State of Indiana, extending from latitude 37° 50′ to about 41° 45′ N. The exact latitude of many places of observation is given, not so much for the American reader or investigator as for those of other countries, notably England and Russia.

My experiments and observations have been carried on almost exclusively out of doors and very largely in the fields, as I consider indoor and breeding-cage observations on this species, except for the purpose

of securing specimens and parasites, of very doubtful value from an economic standpoint or as indicating its normal habits. The observations have many of them been once and often twice substantiated.

In ordinary seasons and throughout the area above indicated the statement made long ago by Dr. Fitch that the Hessian Fly is double brooded is true. While in the southern portion of the State the fall brood of adults seem to appear some weeks later than in the northern part, nevertheless I have found but two destructive broods. Between these two broods, however, is a considerable mass of fluctuating individuals, the true position of which is rather anomalous.*

At LaFayette, Ind., latitude 40° 27′, wheat plants were transferred from the fields to the breeding cages April 5, 1890, and kept out of doors. The seed producing these plants had been sown the preceding September 3. On April 17 a female emerged, and a male appearing soon after, these, on April 22, were both placed together on young growing wheat planted in a breeding cage, out of doors. From these adults were secured June 8. The attempt was made to follow the offspring of these, but failed on account of the wheat being killed by rust. On June 7, and also on the 14th, 1888, in the same locality, adults were observed ovipositing, the eggs being placed on the youngest and most tender shoots, and there was every evidence that these eggs developed through the larval to the flaxseed stage by early July. Besides, I have observed in the same locality late-growing shoots literally overrun with very young larvæ on the 26th of June, and found larvæ as late as the 10th of July.

On October 16, 1887, Mr. W. S. Ratliff, who made a great number of experiments for me, near Richmond, Ind. (latitude 30° 51′), secured adults from a small plot of wheat plants which appeared above the ground September 4. From a plant from this same plat that had been transplanted indoors, he secured an adult female 11 days earlier. In either of these cases with favorable weather the female could have sent her offspring into the winter in the flaxseed state. Mr. Ratliff also observed adults on July 10, 1887. At La Fayette, Ind., the same autumn, I saw females ovipositing on November 3, in a temperature of 64° F., among the plants. From a plat sown August 13, and which came up on the 17th, I obtained adults of both sexes on October 1, 44 days after the plants appeared and 48 days after sowing. That larvæ, even though quite immature when winter begins, may survive till spring has been demonstrated again and again, and was especially true of the exceedingly mild winter of 1889–'90. In fact, by a series of sowings all

* Dr. Fitch states that the eggs of the fall brood are deposited in the State of New York early in September, and also that "the deposit is doubtless made later to the south of us than it is here in New York." (*Seventh Report.*) Mr. Edward Tilghman observed oviposition in Queen Anne's County, Maryland, about latitude 39° to 39° 30′, during the second week in October, and mentions it as of usual occurrence. (*The Cultivator, May,* 1841.)

stages of the insect can be produced continually from April to October, and by keeping a cage indoors I have produced adults in abundance in January.

As Dr. Lindeman has well stated, the puparia are greatly influenced by environment, temperature, etc., and this is probably true of the other stages, larvæ of different ages being, for all we know, influenced to a different degree. To these facts must be added another of considerable moment, viz, while nominally two brooded, flaxseeds collected by me in the spring of one year have lived over to the spring of the following year. This is also true of at least one of the parasites of the species. How far the number of these interlopers is augmented by a retarded development of greater or less extent it is impossible to say, but that there is an accession through this means there can be no doubt. In fact, it would appear as though nature had in this way provided against the extinction of the species.

Now, is it proper for us, from these scattering individuals, to attempt to construct distinct broods? It seems to me not. I have several times sown wheat at La Fayette early in July and never had it seriously infested by Hessian fly until late in August or early in September. Very young larvæ were exceedingly abundant early in October of this year in a field of early-sown wheat near La Fayette.

It is true that observations during a single season, in a single locality, might produce apparently good evidence of a third brood, but a continued close study of the species in such locality will probably show it unfounded. That these aberrant individuals may, under favorable conditions, collect or "bunch" together in certain fields is probably true, but my own experience has been that the following year this irregularity will have disappeared or have been reduced to a minimum by the effect of the weather during midsummer and winter. On June 24, 1887, near Princeton, Indiana, latitude 38° 23′ N., I found a field of wheat, sown about the first of the preceding November, literally alive with larvæ from one-fourth to nearly or quite full grown. There were no pupæ to speak of in this field at the time, but in other fields in the vicinity these were abundant, but here there was no larvæ to be found. At this date wheat harvest was at its height. The late-sown field had evidently attracted the late-appearing adults of the fall before, and their progeny, living over in this field, as delayed larvæ, emerged correspondingly late in the spring, giving rise to the generation of larvæ observed by me. My reason for taking this view is that I have several times tried to draw off the spring brood of flies by offering them young plants on which to oviposit, but have always failed, as they seemed to prefer tender shoots of older plants to the young plants themselves. In the fall this characteristic seems to be somewhat the reverse, although even then, if attacked after tillering, the tillers will be chosen instead of the main stem. The fall brood of adults is probably the migratory brood, and their power of detecting wheat plants is almost phenomenal.

I have drawn them to a small plat of wheat sown in a secluded corner of my garden, in the midst of town, fully half a mile from any wheat fields. But, be this as it may, a second brood of larvæ in June would be rather difficult to sustain, as the puparia of the earlier part of the month are known to remain in that stage until September. Neither have I been able to secure any better evidence of a brood originating in volunteer wheat during July and August. Puparia are to be found every year from one end of the State to the other in this volunteer wheat, but here in Indiana I have never found these sufficiently numerous to imply a distinct brood. Professor Forbes and his assistants, working in Illinois, appear to have a greater confidence in this extra brood than myself, although, as will appear farther on, our experiments were carried on the one perfectly independent of the other, though only a few miles apart.

My attention has been called to the condition of this field near Princeton, by Honorable Samuel Hargrove, member of the board of trustees of Purdue University, and also a member of the State Board of Agriculture, who willingly agreed to further aid in the investigations by sowing for me plats of wheat at intervals of about 2 weeks, beginning as soon as possible after harvest. Being detained in Louisiana myself until nearly the 1st of August, and the weather being exceedingly dry, no plats were sown until August 4, 1887, followed by another on August 22, and a third September 5. These were sown on one of Mr. Hargrove's farms, about 10 miles northeast of Princeton.

The first two sowings, owing to the drought, came up sparingly and about the same time. The third was also affected by drought, and did not come up until about the 1st of October. These plats were sown along the lower edge of a high, rolling stubble field, which had been too dry to plow, and in which I had found an abundance of flaxseeds the preceding June.

These plats were examined by me on October 8. The two earlier-sown plats had thrown up a good growth of plants, which had tillered finely, being along a low ravine. On these plats I found a number of larvæ, which were nearly or quite grown, and a less number of flaxseeds, one of which was empty. Besides these, the plants were literally alive with very young larvæ, so young, in fact, that they had not yet lost their reddish tint. The third plat had sent up the normal number of plants, which were now in the second leaf. These plants had not appeared in time for the earlier deposited eggs, but were even more seriously infested by young larvæ than the plants of the two earlier plats. One of the plants from the last plat is before me, and contains twenty-six young larvæ, all of which must have hatched from the eggs only a few days prior to my observations. Now, from whence did the progenitors of these young larvæ originate? Most assuredly not from volunteer wheat, because there was none. Not from my earlier-sown plats, else these would have shown the effect. There are, it seems to me, but two

other sources from which they could have come, viz, the stubble, which I know to have been infested, and grasses, which we have no knowledge of the species affecting.

These plats were plowed up soon after examination, as I was afraid to allow them to stand thus, a menace to the adjoining fields the following spring, though the plants would have probably been destroyed before even a small portion of the larvæ matured.

From all the information that I am able to gather, the usual time of appearance of the fall brood of adult flies in southern Indiana is the last portion of September, or some years the first days of October. This is, I believe, the opinion of the most observing farmers, including Hon. J. Q. A. Seig, of Corydon, Harrison County, who is as familiar with the earlier stages of the pest and its effect upon fall wheat as I am myself. Mr. J. P. Londen, of Sharp's Mills, same county, stated that wheat sown on October 1, 1886, was damaged 50 per cent., while that sown on the 6th was injured only 15 per cent. Mr. J. A. Burton, writing from Mitchell, Lawrence County, November 24, 1887, gave the results of his examination of wheatfields as follows: Fields sown September 8, about one plant in 8 infested; sown September 15, about one plant in 12; sown September 22, about one plant in 50, and sown October 1, seemingly free from injury. The observations of these gentlemen also coincide with my own, made in November, 1888, in Harrison and Posey Counties. Therefore, from all the information which I have been able to gain, the best season for wheat sowing, to avoid the attacks of the Hessian fly in extreme southern Indiana, is soon after the 1st of October. Exactly how far northward this advice will apply I am unable to say, but am inclined to think it would cover territory laying between latitude 38° and 39°, and possibly 39° 30′, although near the northern limit it would probably be safe during ordinary years to sow soon after September 25.

During the years 1887 and 1888 Mr. W. S. Ratliff made a large number of very careful observations, and sowed a series of plats of wheat on different dates near Richmond, Ind. In 1887 plats were sown August 5 and 29, September 12 and 26. All of these plats were attacked and more or less injured except the last, which as late as December 19 showed not the least injury by the Hessian fly. Up to May 31, 1888, there was very little injury to this plat, and even on the above date there were very few larvæ as compared with the number on the others. From this date on till July 11 the plats were all injured by black and red rusts, Chinch bugs, and the Wheat Stem maggot, the greater injury appearing to fall upon this, so that at harvest, July 11, the last was the poorest of all in yield, that sown August 15 being the best. The sowings of 1888 were as follows: September 6, 20; October 4, 22; November 1. On November 14 the first plat was found to be infested by larvæ of the Hessian fly. During June, 1889, Chinch bugs again attacked the plants growing on these plats, and the grain aphis seriously

injured the later sown plats, so that at harvest, July 5, these latter were the poorest of all, the other three averaging about alike. All of these plats during both years had been sown in narrow strips among corn along one side, the remainder of the field being corn, and later also sown to wheat, thus bringing the latest-sown plats between those sown earliest and the entire field itself, as appeared to me, the severest test to which I could subject the several plats. The results, while not conclusive or even entirely satisfactory, indicate that in that latitude about September 25 is, generally speaking, a good time to sow wheat to escape fall attacks of the fly and winter killing. A series of plats sown for me by Mr. Miles Martin, of Marshall, Parke County, Ind., in very near the same latitude as Richmond, but nearer the western border of the State, gave rather more conclusive results, the sowings of September 22 being almost entirely exempt from the attack of the Hessian fly, while earlier plats were infested.

In regard to my own experiments here on the Experiment Station grounds at Lafayette, I may state that I have never been able to provoke a disastrous attack of the pest, though there has been nothing left undone which could possibly induce the adult flies to oviposit at any time between March and December; and there is probably not a month between these dates during which the insect could not have been found in all of its stages. The two destructive broods, however, invariably appear in May and September; in the latter case usually before the 20th.

My own experimental showings were rather more elaborate and extensive than those of any of my correspondents, comprising a number of varieties and extending over several months. Without going into details, the experiments and results may be summarized as follows: 1887, plats comprising the varieties Michigan Amber, Clawson and Velvet Chaff, each one width of a grain drill twenty rods in length, were sown on the following dates: August 13, 27; September 10, 24; October 8, 27; November 5, 19. The autumn was very dry, and the plants of the first six plats went into winter in poor condition, being very small, while the last two sowings did not come up until the following spring. The severe winter destroyed the plants so generally, that only the first three produced sufficient grain to pay for harvesting. These were also the only ones to suffer from the fall attack of the fly, the first producing adults October 1. Plat 8 was attacked on the following June, and on the 26th was badly infested with young larvæ, full-grown larvæ and puparia, the latter, the most numerous, were found on the 16th of July. The plats harvested produced a poor crop, but the Michigan Amber ranked first, Velvet Chaff second, and Clawson the poorest of all.

The condition of the Hessian fly in these three plats, at the time of harvest, July 10, 1888, may be inferred from the result of examinations made on this date.

Empty flaxseeds	15
Containing healthy pupæ or parasites	69
Larvæ	16
Total	100

August 3, the state of the insect in these same plats was as follows:

Empty flaxseeds	53
Containing healthy pupæ and parasites	47
Total	100

The condition of the insect on September 1, as shown by examination of the stubble, is indicated below:

Empty flaxseeds	55
Healthy flaxseeds	28
Parasitized flaxseeds	17
Total	100

Notwithstanding the per cent of healthy puparia passing the summer was small, there is little probability that many adult flies emerged. A plat of the same dimensions was sown July 16, along one side of the first three sown the previous fall, the plants of this last sowing coming up ten days later. This plat was closely watched. After July 17 only an occasional larva was found. By August 4 plants had been destroyed by the combined influences of chinch bugs and dry weather, but a second plat has been sown adjoining, and the plants of this appeared above ground on August 6. On September 4, 200 plants were examined and but two larvæ were found thereon. A second examination of the same number of plants from this plat, on September 15, revealed a small number of young larvæ. A third examination of this plat on October 6 showed about 1 per cent of the plants to be infested. Stubble from the three original plats, kept in breeding cages, out of doors, did not give adults until the 17th of September, although it is quite probable that some few were abroad before that date. It will be seen, however, that no great number could have emerged from the stubble, and the increase in the number of empty flaxseeds between July 10 and September 1 is doubtless to be attributed to parasites. This appears all the more probable, as I have repeatedly observed these parasites during July and August emerge in breeding cages, and at once begin to oviposit in flaxseed in the stubble from which they had themselves emerged. The percentage of healthy puparia reaching September in safety, however, was probably unusally small, as experiments on the same ground the following year did not suffer near so much from either fall or spring attacks. Another feature of these experiments is, that it strongly indicates that the larger per cent of the parasites emerge prior to the 1st of August. Indeed, stubble from the entire length of

the State, collected in June and placed in breeding out of doors here at La Fayette, has indicated the truth of this.

The sowings of 1888 were made on August 30, September 18, October 3, 6. Of these, only the first sown were attacked in the fall, that sown on September 18 being in the best condition the following July. During May, 1889, the plants of these plats were found to be much less infested than some fields a considerable distance away, although such fields had been sown on oats stubble, while the ground on which my experiments were located was the same that had been used for this purpose the previous year.

The sowings of 1889 were continued on the same grounds, the plats being sown September 3–20, October 4–18, November 4. The autumn attack was the most severe on the first plat, but the extremely mild fall and winter was so favorable to the development of the flies that the spring attack was unusually severe, and appeared to fall upon the three earlier sown plats with about equal force. The later sown plats, though the plants were much the younger, did not suffer so much, but these were very seriously affected by the weather during early spring.

These experiments appeared to indicate that, in this latitude, while wheat sown as early as the last of August may under favorable conditions and during particular seasons produce as good or even a better crop than when sown at a later date, yet such cases are the exception and not the rule; but that wheat sown as soon as possible after the 20th of September stands the best chance of evading the attacks of the fly and withstanding the unfavorable weather, the regular operations of the University farm during the last seven years certainly substantiate. It is the custom with the experiment farm, each year, to sow the regular field crop at this time, and in no case has severe injury been sustained from attacks of the Hessian fly. Fields on adjoining farms sown at earlier dates have frequently been seriously injured, although this has not invariably followed.

Another series of experimental sowings was carried on for me by Hon. W. A. Banks, near La Porte, Ind., about latitude 41° 35′. The first series of these sowings was begun in August of 1887. The sowings of 1888 were not carried on under Mr. Banks's immediate supervision, and were of little value. No experiments were made in 1889, but a well planned and carefully executed series were sown in the fall of 1890. The series of 1887, each of which comprised two widths of a grain drill, extended along one side of the field about 60 rods in length, the first of which was sown on August 13, the plants appearing above ground within a few days. The second sowing was on August 23, a third on September 2, the fourth September 12, the fifth September 22, the sixth and last on October 7. These plats were visited by me on October 14, and their condition found to be as follows: The first was found to be infested by great numbers of larvæ and puparia, some of the shells of the latter being empty, and the plants were seriously dam-

aged. The second plat was even worse injured than the first, and the third much worse than either of the others. The fourth appeared to be almost as badly infested as the third, but it had only partly tillered, and hence there was a better prospect for it to throw up unaffected shoots. The fifth had not tillered, and was only very slightly infested, with very young larvæ, while the sixth was not yet up.

On April 12, 1888, the plats were visited again. About 25 per cent of the plants on the first three plats appeared to have survived. The fourth was apparently 50 per cent better, the fifth was in almost as good shape as the fourth, while the sixth was backward, the plants being small and thin on the ground.

The estimate yield, made by Mr. Banks at time of harvest, on the basis of 20 bushels per acre as an average yield, was as follows: First plat, 50 per cent; second, 50 per cent; third, 65 per cent; fourth, 90 per cent; fifth, 70 per cent. The remainder of the field was sown on September 2, and shared in the destruction in common with plat 3. Another field at some distance from this was sown about September 20 and sustained no material injury.

It will be observed that the first three plats were sown almost at the same time as the first three at La Fayette, yet stubble from the first three plats at La Porte, collected on September 2 and placed in a breeding cage beside another containing stubble from the first three at La Fayette, gave adult flies nearly a week earlier. In other words, the majority of the adults from Mr. Banks's plats emerged prior to September 15, while those from my own did not reach their maximum numbers until after the 15th, and from then on till the 25th. In both cases, however, a few stragglers emerged occasionally until early in October. As previously stated, the plats of 1888 were not properly sown, Mr. Banks not being able to attend to them himself; but a visit to the locality on November 8 revealed but very little injury to wheat which had been sown after the middle of September.

The experiment plats of 1890 were sown September 1, 10, 20, 30. These were examined late in October and fully substantiated the experiments of previous years. The sowing of September 1 was considerably injured, while that of the 10th was very seriously affected, as was also a large field adjoining sown but a day or two later. The sowing of September 20 was comparatively free from attack, while that sown September 30 appeared to have almost entirely escaped injury.

The sixth and last series of experiments were made for me by Hon. J. N. Latta, at Haw Patch, Lagrange County, in about the same latitude as La Porte. The sowings were made in 1887, the first being drilled on July 28, but owing to drought the plants did not appear above ground until about the 28th of August. The second plat was sown on August 15, but came up the same time as the first; the third, sown September 1, came up September 6; the fourth, sown September 12, came up September 21; the fifth, sown September 24, came up the

28; while the sixth and last was sown October 12, and did not come up until about the 20th. These plats were examined by me on October 17; the first three and the last sown were very poor, the fourth and fifth promising a fair yield. A field adjoining, sown on the same day as plat 5, did not suffer from the fly and produced nearly an average yield of 20 bushels per acre.

The results of these meager experiments have, as a rule, proven correct in the fields of the farmers. I have not only observed this myself, but it has become well known in the locality that wheat sown before September 15 and after the 30th of the same month seldom produces a good crop, while that sown between the 15th and the 25th is the most likely to escape the attack of the Hessian fly, and, as a general thing winters, as well as that sown earlier.

In summing up the results of this entire system of experiments, it seems that while no exact date can be laid down for the appearing of the fall brood of fly in any precise locality, there is, notwithstanding, a gradual delay in its appearance as we go from the north southward. In other words, there is here a characteristic element in the life history of the species which may be utilized by the farmer to his advantage. Fruit-growers, I believe, estimate that in spring the season advances northward at the rate of about 12 miles per day. This would be a trifle less than 6 days per degree of latitude. If farmers in extreme northern Indiana and southern Michigan can sow their wheat with safety about the 12th to the 15th of September (and we have demonstrated that the fall brood emerges largely prior to the 15th), and farmers in extreme southern Indiana must delay sowing until after the first days of October, there must be a general system of retardation, which, if understood, may be used to advantage throughout the intervening territory.

Starting in southern Michigan on the 12th to 15th and passing 4 degrees south to the vicinity of Evansville, Ind., we should expect about the same condition of the Hessian fly during the first week of October. That is, if we pass the danger line about the second week of September in southern Michigan, we should expect to encounter it again in southern Indiana in the first or second week of October. A considerable correspondence and my own experiments indicate that this is usually true. It is not to be supposed, however, that it is possible for me to give precise dates for given localities, as there is another element which is likely to figure in these calculations, viz, elevation. It has been stated upon reliable authority that "an elevation of 350 feet is equal to 1 degree of cold in the mean annual temperature, or 60 miles on the surface northward."* While we can hardly expect this to influence comparatively level countries like the State of Indiana at least to any marked degree, extensive areas of high table-

* Draper's Intellectual Development of Europe, Harper Bros., New York, revised edition, vol. 1, p. 29.

lands would be apt to show its effect more distinctly. There may also be some obscure influence peculiar to the natures of the different soils.

It will be seen, therefore, that the experiments have fallen far short of settling the whole problem, yet it seems to me that they have been carried as far as profitable, and the matter is now in proper state to be taken up by the intelligent farmer, whose experimental plats are his fields. And it may be added that this is done with a feeling on my part that whatever of truth there may be in the matter will stand as a nucleus about which others may build, while whatever there may be of error will as surely disappear.

THE EFFECT OF THE LARVÆ ON THE PLANTS.

The effect of the larvæ, especially on the young plants, does not appear to be generally understood, and I have myself been able to verify either the figures or descriptions of Fitch and Packard only in exceptional cases. The swollen bulb just above the roots in Fitch's figures gives but a vague idea of the true appearance, while Packard's figure represents plants which have very evidently sprung from seeds only slightly covered by the soil. Besides, the former figure only represents the condition of the plants long after the larvæ have done their work, and the latter, aside from the shoot being shorter, gives no idea of the appearance of an infested stem, as found in nature, growing in the fields. The yellow color of the foliage—there is usually more brown than yellow about it—appears later, after the larvæ are full-fed, and then it is largely, at least, confined to the younger leaves, the older ones, under whose sheaths the larvæ occur, are killed by the freezing weather of winter. In Circular No. 2 of the Agricultural Experiment Station of Purdue University I have given a representation of an infested plant fresh from the field drawn from nature. The plant had been attacked soon after its appearance above ground and had not tillered. The leaves under these conditions are broader, darker green, more vertical and bunchy. The youngest leaf on a healthy plant as it unfolds and pushes upward is of a tubular form and spindle-shaped, somewhat as represented in Packard's figure of a healthy plant. In the case of an affected plant, the stem having been destroyed below ground, the spindle-shaped central leaf is always absent. The difference between a healthy and infested plant is shown by a comparison of figures. If a plant has already tillered, each of the identical laterals, as they are attacked, will begin to take on the form and color above described. It is, therefore, not only possible to detect an infected plant without removing it from the ground, but also to determine the individual tiller infested. Now, while this feature of infested plants is so very clearly marked, at least after the larvæ are one-third grown, and from an economic standpoint of so much importance that it is surprising that it should have been overlooked, yet I can not myself lay claim to the fact by right of discovery, as it was pointed out to me by a farmer in the autumn of 1884, and was

the outcome of circular No. 1, issued in October, 1884, from Purdue University. It was only after testing the stability of this feature in various fields, under widely different conditions, that I placed full reliance upon its permanency. An illustrated circular of inquiry, No. 2, issued by myself from Purdue University during the fall of 1887, brought also a great number of replies, from among which I have selected the two following, because of their widely separated localities and the well-known ability of the writers:

CLYDE, N. Y., *December* 9, 1887.

DEAR SIR: In regard to the appearance of wheat plants infested with Hessian fly, and as illustrated and explained by Fig. 3 of circular, I believe that it is correct in the main, especially the darker color possessed by infected plants over healthy plants, and this is, as you say, quite different from the information given by Fitch and Packard; and you have published this quite constant and true form and condition for the first time, I believe. I had noticed this somewhat a year ago, and in bringing up the destruction done by the Hessian fly in a Grange meeting, I found that a number of farmers reported this very condition, viz: when fields or parts of fields looked extra dark colored and healthy, damage from the fly was to be apprehended there. Still, the yellow color came after a while, especially with early-sown winter wheat in a long autumn or the following spring. I think the spring brood are apt to select tillers.

Truly,

W. L. DEVEREAUX.

Prof. F. M. WEBSTER,
La Fayette, Ind.

UNIVERSITY OF CALIFORNIA, COLLEGE OF AGRICULTURE,
Berkeley, *December* 15, 1887.

DEAR SIR: Your favor of November 28, with circular relating to appearance of grain infested with Hessian fly, received. The appearances you describe are quite characteristic of fly-infested grain here, but it is not seen in the fall, for we do not have any grain above ground at that time. The districts in which the fly is found in this State are of narrow area comparatively near the coast. In these parts it is not usual to sow grain until after the winter rains have wet the ground enough for plowing, and sowing can some years be made as late as the last of February, and still do well. It is better, however, both for the growth of the grain and baffling of the fly, to sow in January if the soil is in proper condition. For these reasons we do not find the flaxseeds until about the first of March, and then it is that the grain assumes the feature you describe. It is a very bunchy growth, with very few yellow leaves and exceedingly few seed stems thrown out. On some of our plats there will not be a single stem, but the grain will remain bunchy and low for weeks, and then will turn yellow and die as the dry season comes on. On other plats there will be a seed stem thrown out here and there, and a few heads will ripen.

Such is my recollection of the appearance of past crops. We do not intend to sow wheat and barley this year on our fly-infested ground, but the pest may follow our sowing on another part of the grounds, and if it will be of interest to you, I will watch the plants and send you specimens.

Yours very truly,

E. J. WICKSON.

Prof. F. M. WEBSTER.

If the soil is rich and the plants are attacked before they have tillered, these last will be thrown out from the roots which are not injured. These, if the fall be very favorable, and the winter does not commence too early, will often winter through and produce stem-bearing heads the following harvest. On the other hand, if the autumn be dry, or the ground be frozen early in the season, the crop will probably prove a failure. This is the reason why some fields will present a much better appearance the following June, and give a much better yield than could have been anticipated from appearances during the fall. The practical value of knowing how to detect the infested plants readily is in that the destruction may be observed and the damage estimated long before the foliage turns brown or yellow, and the fields be plowed up and resown or allowed to remain, as the owner judges best. If resown, it would seem best to replow also. Mr. W. A. Oliphant, of Pike County, southern Indiana, writing me in the fall of 1884, in reply to circular No. 1, stated that of 300 acres he had resown 200 acres after replowing, and 100 acres without plowing. The first yielded him 27½ and the last 11 bushels per acre.

The popular notion in regard to the effect of larvæ on the straw is, so far as I know, usually correct. This year, however, has been an exception, at least so far as southern and central Indiana is concerned. As far north at least as La Fayette the larvæ of the spring brood were located just above the roots, and the straw did not break at the lower joints, as is usually the case, but either fell or was blown over from the roots, the culm usually being uninjured elsewhere. I observed this to a very limited extent at Oxford, Indiana, in 1881. In fields about La Porte, in the northern part of the State, none of this lower attack of the plant was noticed, the larvæ and later the puparia being invariably found just above some of the lower joints. Mr. James Fletcher, Dominion entomologist of Canada, reported at the meeting of the Entomological Club of the American Association for the Advancement of Science at Indianapolis that the wheat about Ottawa, Canada, had this year suffered from the attacks of larvæ of the spring brood in precisely the same manner as I had observed at La Fayette and southward. Quite a percentage of the pupæ in the fields about La Porte were located so high up the stem as to render it probable that they would be carried away with the straw. As yet I have not found a good reason for this difference, but have a vague idea that the killing down of the plants during the preceding March might have had something to do with it, as this was less severe in the northern part of the State.

THE EFFECT OF THE WEATHER ON THE DEVELOPMENT OF THE FALL BROOD.

It is quite probable that some autumns are more favorable for the development of the insect than others, but just what the favorable influences are is not well understood. Mr. Ratliff, at Richmond, saw an adult emerge from the pupa on October 16; the wheat which it infested appeared above ground on September 4. Between these

two dates, Mr. Ratliff's notes give the following record of minimum temperatures through which the insect must have necessarily passed.

September 23 (frost)	26°
October 6 (light frost)	26°
October 11 (light frost)	34°
October 12 (light frost)	26°
October 14 (heavy frost)	24°
October 15 (frost)	26°
October 16 (light frost)	29°

Rains on September 11, 26, October 10. Total precipitation during September and October, 2.50 inches.

At La Fayette, the same year, I found adults ovipositing on November 3, but of the origin of these flies of course nothing was known. The temperature through which these must have passed, supposing the eggs from which they evolved were deposited after September 1, was as follows:

	Min. temp.
September 23	39°
September 24 (first frost)	29°
October 11	39°
October 12 (frost)	29°
October 14 (frost)	33°
October 15 (frost)	31°
October 16	38°
October 19 (frost)	31°
October 20 (light snow)	37°
October 21	29°
October 22	21°
October 25 (frost)	19°
October 26 (frost)	21°
October 27 (frost)	21o
October 28 (frost)	28°
October 29	33°
October 30 (frost)	19°
October 31	28°
November 1 (frost)	28°
November 2 (frost)	36°
November 3 (frost)	32°

Rains on September 7, 13, 14, 22, 27, 28, 29, 30, October 3, 9, 10, 12, 23. Total rainfall, 4.64 inches.

From this it will be observed that the adult flies may emerge and oviposit under what we suppose to be very adverse circumstances. To what extent the eggs and young larvæ are able to withstand such weather I have no facilities at present for demonstrating. The major portion of the small brood of flies, however, emerge during a more favorable period, and for meteorological aid against these we can only look to the dry, hot weather of July and August, though to the south a portion of September might be included. But the straggling individuals, which, as I have proved, may originate from stubble, volunteer, or even early sown grain, and which I myself can find no satisfactory reason for not considering either the retarded or accelerated individuals of either one or the other or both broods, have it in their power to reproduce a considerable progeny, which, though of themselves not a serious

menace to the crop, yet, added to that of the remainder of the brood, greatly increase the probabilities of serious damage. For these a long, mild autumn, extending into December, would appear to be exceedingly favorable, as it would enable their progeny to enter winter in a comparatively hardy state, and probably produce late appearing larvæ the following year simultaneously with or but little in advance of the progeny of the earlier appearing adults of spring. In other words, the one winters as advanced puparia or unemerged adults, the other as advanced larvæ or newly formed puparia. It thus appears that while the autumn usually has little effect on the major portion of the fall brood, a mild October and November may emphasize the destructiveness of the pest. So far as observed by me, a damp spring, even though a cold one, is also favorable to the development of the insect, while dry, hot summers are as unfavorable, and cause serious mortality to the earlier stages of the fall brood of adults.

PREVENTIVE MEASURES.

These may be noticed as follows: Sowing at the proper time; burning the stubble; rotation of crops; sowing long, narrow plats in late summer as baits; applying quick-acting fertilizers to seriously infested fields in the fall in order to encourage attacked plants to throw up fresh tillers, and to increase the vigor of these that they may make sufficient growth to withstand the winter.

None of the measures are original with me, and in fact the most of them are as old as the history of the species itself. There is certainly much to be gained by the farmer in timing his sowing so as to avoid the larger part of the fall injury, and if all farmers of a neighborhood would sow about the same time even a serious outbreak would be so diffused as to lessen its injury.

The burning of the stubble after harvest, when it is practical to do so, is usually recommended by the majority of writers. The plan is criticised by some authors on the plea that the parasites are also destroyed, which, if allowed to continue, would themselves overcome the fly. This idea has always appeared to me to be both theoretically and practically wrong. If only the normal number of wheat plants allowed by nature to spring up under a perfectly natural environment were produced, then the theory would be correct, because nature would then be working out her plans from the beginning. As the facts exist hundreds of thousands of plants are produced where nature intended but one. Her domain is invaded and her law defied at the beginning. The Hessian Fly is itself a parasite, the wheat plant being its host, and what we term its parasites are practically only secondaries. In the Hessian Fly nature has an efficient servant in controlling the wheat plant, and the parasites of the former seem to be on guard to see that the duty is not overdone. Now we outrage nature and expect that she will uphold us by destroying these servants and permitting the indignity to go on.

With this state of affairs the American farmer has found that the Hessian Fly will be overcome by its parasites only temporarily, and then at the expense of a larger per cent of at least one crop. By burning the stubble we destroy all of the pest and also numerous other enemies which are to be found in the fields at the time. The present season, however, many of the flaxseeds were so situated that it is doubtful if enough heat would have reached them to have destroyed them.

In a rotation of crop the adults are obliged to travel about in search of the fields, and there is a greater chance of their being destroyed while thus engaged. This, however, has its exceptions, as we observed at New Castle, about 30 miles northwest of Richmond, Indiana, on November 17, 1888. The whole field had been sown in standing corn, a portion of it about the 5th of September and the remainder considerably later. The early sown portion had been seriously attacked and at least 85 per cent destroyed; the later sown portion was only slightly injured, as was late sown wheat generally in the community. Here at the Indiana Experiment Station the plan of rotation is as follows: Corn one year, followed by oats one year, wheat one year, clover and grass two years. The wheat fields are never seriously affected by the ravages of the Hessian Fly.

Sowing narrow strips about the fields, early in the fall, as decoys, was long ago strongly advocated by Dr. Fitch, but the advice has been, so far as I have observed, totally ignored by the farmer. While it is hardly possible to thus entrap the major part of the fall brood of larvæ, it is certainly possible to entice to these plats the stragglers and interlopers, which we have shown to be capable of considerable injury. In this way the farmer can, in a measure, continue the influences of summer and winter in sharply separating and defining the two broods. In other words, while he can not eradicate the pest in this way, he can weaken its power to commit serious injury. It is very doubtful if the volunteer wheat, springing up after the wheat has been plowed, can be used as decoys, and if allowed to stand until the date of sowing the fields, these volunteer plants should, by all means, be plowed under as deeply as practicable, or grazed off by pasturing. Simply killing the plants will not do, as has been illustrated by the experience of Mr. Oliphant, previously cited, and by the observations of Professor Forbes in Illinois.* If volunteer wheat is allowed to stand at all, it should not be for over a fortnight. The proper time for sowing these decoys will probably vary with the latitude. For northern Indiana they should be sown during the latter part of August, and in the southern part of the State not later than the first week in September. To the north and south of this I have, as previously stated, no definite information as to the date of appearance of the fall brood of flies, and hence can not undertake to settle the date of sowing. These decoys should not be permitted to stand over four weeks at the farthest, and should be *plowed*

* Bulletin 3, State Ent., Ill., p. 48, 1887.

very soon after the crop is sown, turning the infested plants under and thoroughly covering them. Simple cultivation, whereby the plants are only killed, would probably only destroy a portion of the insects, the full-grown larvæ very likely going through the remainder of their transformations.

The application of fertilizers is, I believe, here in this State confined to the poorer soils, and there more for its general effect on the crops than as against the effects of insects. The idea in late sowing is to retard the plants so that they do not appear until after the greater part of the fall brood of flies have appeared and died, then to overcome the effect of this delay by aiding the plants to make the greatest possible growth before winter closes in, which will the better enable them to withstand its rigors. In this direction, it would seem that the application of proper commercial fertilizers would pay by the effect upon the growing plants, even though the land itself was not in actual want of such treatment. The application to a field which has previously been seriously damaged, with a view of encouraging the throwing out of fresh tillers, is for practically the same purpose; and if there is a tendency to throw out the later shoots freely, if not too late in the season, many may be enabled to secure sufficient vigor to sustain them until spring. Whether it would be more profitable to plow and resow than to try to secure a crop from the infested field by the aid of fertilizers is, of course, a question which each farmer must decide for himself in accordance with the time of year and extent of injury already done.

These measures are all of them practical and entail little if any unusual expense. In fact, good farming presupposes that the most of them will be carried out as among the essential elements of the business. Where clover is to follow wheat it of course precludes the burning of stubble or the destruction of volunteer plants, but it necessitates the rotation of crop, and decoys can be sown and the seeding delayed. It is hardly possible for a farmer to become so situated that he can not carry out some of these measures, and if this were done generally, and every year, the Hessian fly would, in all probability, become of so little importance that it would cease to enter seriously into the problem of successful wheat growing.

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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 24.

THE BOLL WORM OF COTTON.

A

REPORT OF PROGRESS

IN A

SUPPLEMENTARY INVESTIGATION OF THIS INSECT.

MADE UNDER THE DIRECTION OF THE ENTOMOLOGIST

BY

F. W. MALLY.

(PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

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1891.

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LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., February 27, 1891.

SIR: I have the honor to submit for publication Bulletin No. 24 of this Division. It consists of a preliminary report upon the special investigation of the Cotton Boll-worm (*Heliothis armigera* Hübn.) which was authorized by Congress in the bill making appropriations for the use of the Department for the fiscal year 1890–'91.

Respectfully,

C. V. RILEY.
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

INTRODUCTION.

The present bulletin consists of a report made by Mr. F. W. Mally upon the progress of the special investigation of the Cotton Boll-worm which has been carried on under the Division since the appropriation became available, July 1, 1890. Mr. Mally has had charge of the minor details of the investigation, and has been constantly in the field since last July. He also summarizes the results obtained by Messrs. McNeill and Booth. The Boll Worm was treated at some length in the Fourth Report of the U. S. Entomological Commission, and the chief object of the present investigation was to conduct further experiments with remedies, as well as to verify the value of those already employed. A thorough series of experiments has been planned with the diseases of Heliothis and allied insects, in the hope of being able to practically utilize them. Incidentally I have desired to ascertain new facts, if possible, and to verify or disprove what has been previously written in connection with the life history and habits of the species.

The observers have all been hampered in their work by the unexpected lack of material. The funds were not available until the season was three-fourths spent. The observations so far made will, therefore, have to be supplemented the coming spring and summer. It transpires that the ravages of the Boll Worm have been overestimated, and that while from 20 to 30 per cent of the bolls are damaged in an average season in Mississippi, only about one-third of this damage is done by this insect. Several other species which do work somewhat similar to that of the Boll Worm are treated in this report. Some new food-plants have been found, and a careful study has been made of the habits and life history which are here treated with more care and detail than has heretofore been given to the subject. Two new parasites have been discovered, and observations have been made which show that the egg parasite (*Trichogramma pretiosa* Riley) is an extremely important factor in the economy of this insect, as it is, also, in that of the Cotton Worm (*Aletia xylina* Say), and the Grass Worm or Fall Army Worm (*Laphygma frugiperda* Smith & Abbott). A careful count shows that 84 per cent. of the eggs were destroyed by this useful parasite. All of the old remedies have been once more tested, and the use of corn as a trap crop is again shown to be one of the most satisfactory means of protecting the cotton crop. The old subjects of attracting the moths to lights and poisoned sweets have once more been carefully considered, and my former conclusions have been confirmed, that there is little to be hoped for from either of these methods. The pyrethrum experiments, from which I had much

hope, have not proved very favorable, while experiments with a large series of other vegetable insecticides have given no practical results as yet.

The experiments with contagious diseases can not be reported upon in any detail at the present time; but a large number of cultures of several diseases of the Imported Cabbage Worm, the Bronzy Cutworm and of two other Noctuids have been secured and carried through the winter. What may prove to be a specific disease of the Boll Worm has also been discovered, and cultures have been obtained. It results from the few experiments made that the Boll Worm is probably susceptible to the Cabbage Worm disease, but positive statements can not be made until these experiments are confirmed by those of another season. A bacteriological laboratory has been established at Shreveport, Louisiana, and has been well fitted out with the necessary apparatus, so that work in this direction the coming season will not be hampered, except in the case of an unexpected paucity of Boll Worms.

C. V. R.

LETTER OF TRANSMITTAL.

SHREVEPORT, LOUISIANA, *February* 19, 1891.

SIR: In compliance with your request I have made out a report of progress of an investigation of the History and Habits of the Boll Worm (*Heliothis armigera* Hübner), carried on under your instructions since July, 1890, and submit the same herewith. The treatment of the various subjects is not at all in detail and has only been made complete enough to give an adequate conception of what has been done, the present status of the investigation, and what remains to be accomplished in the future.

Very respectfully yours,

F. W. MALLY,
Assistant Entomologist.

Dr. C. V. RILEY,
United States Entomologist.

THE BOLL WORM OF COTTON.

DESTRUCTIVENESS.

The damage to corn by the Boll Worm is difficult to estimate, owing to the nature of the attack. Its ravages in the "bud" of the young plants and later in the ends of the ears taken collectively no doubt are considerable, though no definite per cent can be given. Tomatoes, cucumbers, and melons also suffer more or less seriously from its ravages. It is the attack upon cotton which is considered most serious and supposed to be of great proportions. To determine the amount of damage to cotton in the regions visited the past season the following studies were made. The first was made August 14, in a large field of upland cotton surrounded by woods. Two rows were taken at random in the field; the first was rank high cotton, the second a smaller growth. About 10 feet of each row were marked off and all the bolls on the plants in each counted. (See Table I.)

TABLE I.

Row.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total.
1.........	290	2	95	389
2.........	270	1	43	314

The next study was made September 16, in a small field of rank bottom-land cotton. The first five plants were taken at random, the next fifteen successively in one row. (See Table II).

TABLE II.

Plant.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total.
1........	40	7	5	52
2........	21	2	13	36
3........	4	2	0	6
4........	30	3	20	53
5........	34	10	34	78
6........	19	11	20	50
7........	18	2	0	20
8........	35	9	15	59
9........	17	9	12	38
10........	70	6	9	85
11........	33	7	1	41
12........	42	4	9	55
13........	49	0	4	53
14........	3	0	0	3
15........	10	0	0	10
16........	33	2	2	37
17........	25	2	11	38
18........	72	2	24	98
19........	17	0	3	20
20........	7	0	0	7
Total ...	579	78	182	839

September 17, a similar study of twenty-one successive plants was made in another portion of the same field. (See Table III).

TABLE III.

Plants.	Worms.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total.
1........	1	33	4	13	50
2........	1	23	1	1	25
3........	2	60	3	2	65
4........	0	30	3	1	34
5.......	2	41	3	8	52
6........	0	65	3	0	68
7........	1	11	1	4	16
8........	0	29	1	1	31
9........	0	53	3	1	57
10.......	2	53	5	1	59
11	1	24	5	14	43
12.......	0	63	6	25	94
13	0	24	0	5	29
14	0	19	8	3	30
15.......	0	23	9	12	44
16.......	3	88	13	30	131
17.......	0	22	4	5	31
18.......	0	36	0	2	38
19.......	0	14	0	0	14
20.......	0	20	0	11	31
21.......	0	49	6	39	94
Total.	13	780	78	178	1,036

Table I should not be included in the table of percentages, since its data were obtained early in the season, before the Boll Worm had really become well established in cotton. Omitting table I we have the following table:

TABLE IV.

Percentages from Tables II and III.

Table.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total loss.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
II	.690	.092	.218	.310
III.	.753	.075	.172	.247
Average.	.7215	.0835	.195	.2785

The four preceding studies were made by a count of what was actually found on the plants at the time of observation. September 18 only bolls and forms which had fallen were collected and examined. The result is given below:

Number bored by Boll Worm.. 167
Number shed from other causes... 362

Total.. 529

Taking the average of the total loss found in the same field on the two preceding days, and tabulated as Tables II and III, and again in Table IV, these 529 bolls may be considered as equivalent to the count-

ing of 1,900 bolls by the method of Tables II and III. This study may therefore be given as below:

TABLE V.

	Number.	Per cent.
Good bolls	1,371	.722
Loss by Boll Worm	167	.088
Loss by other causes	362	.190
	1,900	1.000

Averaging this result with that of Table IV we have the table given below as the result:

TABLE VI.

Data.	Good bolls.	Loss by Boll Worm.	Loss by other causes.	Total loss.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Table V....	.7215	.0835	.195	.2785
Study V.....	.722	.088	.190	.2780
Average...	.72175	.08575	.1925	.27825

The above calculations certainly give the Boll Worm as much credit as it deserves, and for the following reasons: The observations were made after the cotton had been "laid by" late in July, therefore the fallen bolls collected from the ground in September covered what had fallen during August and September. This is the period of greatest damage to the cotton. No cornfields near by to lessen and detract from the egg deposition on cotton. This in addition to the consideration of the injured fruit actually on the plants but which was likely to shed, certainly does not make the results arrived at much below the entire damage done during that period.

From the results given above and from subsequent observation it is evident that bottom-land cotton is worse infested than the "hill-country" cotton. Further, even in the same field, as is shown by the record of plants 5 and 10 of Table II and plants 12, 16, and 24 of Table III large, rank, leafy cotton plants, bearing a great number of forms and bolls, are subject to much more serious attack.

The number of forms and bolls which one worm may destroy during its period of existence can only be approximated. From the rate of feeding during favorable conditions and when the larval state is about 15 days the number eaten into may range from ten to twenty. During the longer periods of larval existence caused by unfavorable conditions, the worms are inclined to move about more and perhaps injure more individual fruits, though the absolute amount eaten is not much greater.

What the extent of injury due to Boll Worm over the entire State of Mississippi was the past year will be seen from the closing weather and crop report of Prof. R. B. Fulton, observer, U. S. Signal Service,

University, Mississippi, from which is quoted the following: "In the southern part of the State reports show that on account of injury by Boll Worms and shedding, due to wet weather, the cotton crop will be short from 30 to 40 per cent. of last year's yield. * * * In the northern section the Boll Worm did no material damage." It may further be added that upon application to Mr. George E. Hunt, chief signal officer U. S. Signal Service, New Orleans, Louisiana, for weather crop bulletins and the names of observers who had reported much damage to cotton by Boll Worm last season, he replied that no material

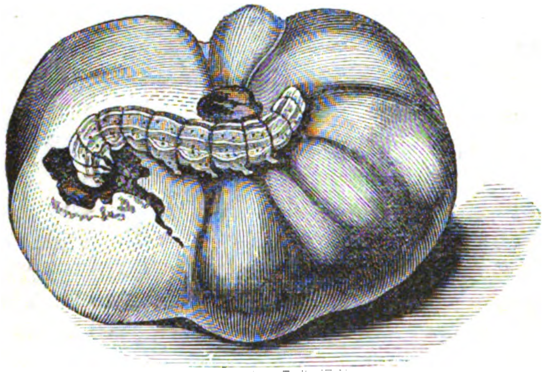

Fig. 1. *Heliothis armigera*: full-grown larva eating into a tomato—nat. size (after Riley).

damage was done from that source and none had been reported by any of the volunteer or other observers. From this information as also the facts shown by the preceding tables it is quite evident that the depredations upon cotton by Boll Worms have been greatly overestimated. If the statements of planters living in the regions where observations were made are accepted, the Boll Worm was fully as numerous if not more so than in previous years. Nearly all agreed that the damage was fully up to the average, others thought it above the normal, but none estimated it as being lower than usual. These statements together with the almost daily reports obtained from interviews that "one-fourth or one-third of the crop was being ruined" (?) led to above careful studies. The results simply show that on the whole the planters fail to distinguish the Boll Worm ravages from those of other insects, from physiological phenomena of the cotton plant, and lastly, from some of the fungoid diseases. In order to assist the planters in this matter a few observations have been added at the close on "Other insect ravages easily confused with those of the Boll Worm."

FOOD PLANTS OTHER THAN COTTON.

Corn.—The habits of the Boll Worm when feeding on corn have been so fully presented in the Fourth Report U. S. Entomological Commission, pp. 359–361, that only such observations will be given as verify

important points or add to our knowledge of the species. The manner of attacking the ears of corn and the semi-solid excrement of the worm which is left behind along its path into the ear, paves the way and provides a fertile soil for the germination and subsequent growth of all kinds of molds. The additional decay resulting in this way, aided by the ravages of Dipterous and other larvæ which revel in such matter, perhaps fully equals the actual damage done directly by the worm. In large fields of corn not often more than one large worm is found in a single ear, but when the fields are small, and especially when surrounded by cotton fields, there are often three or four nearly grown worms in a single ear, and perhaps as many more newly hatched ones. This is a direct result of the preference of the moth for the corn when the latter is in close proximity to cotton fields and of suitable age. When the field is small the female often passes through it several times during a single flight, depositing eggs as she does so. In this way I have often observed the same female deposit eggs three times on the silks of an ear of corn during a single visit. This of course is not the normal method of deposition, and occurs only under the circumstances mentioned. If it were so the numbers of worms would be greatly reduced through the agency of their cannibalistic habits, to be discussed hereafter in considering the history of the worms. Other females visiting the field may also deposit on the same ears of corn, and so on. As a result of this as high as fifteen to twenty-five eggs have been found on the silk of a single ear of corn, and in addition as many more on the husks and leaves.

In regions where corn is cultivated extensively a second crop is planted late in July to produce a fodder crop by the end of the season. These fields are invariably badly infested. When these are near cotton fields they afford a great protection to that crop.

Except on cotton, hereafter considered, no observations of special interest were made on any of the other well-known food plants, though it was noted that the tomato crop suffered severely from Boll Worm depredations.

Other Plants.—As additional food plants of economic importance which are attacked by Boll Worm are to be mentioned the muskmelon, watermelon, and cucumber. The cucumber is attacked usually by eating a hole near the base from below up into the center and then tunneling the length of it to the anterior end. The melons are usually bored from the under side near the base, but occasionally at almost any other point. The female was seen depositing on the following weeds: *Helenium tenuifolium*, *Amarantus retroflexus*, *A. spinosus*, probably *Erigeron canadense*, and one undetermined species of *Panicum*.

It was evident, however, that the young worms did not relish any of the above weeds as food plants and left soon after hatching. This was further verified by taking some branches of the plants just named to the laboratory and placing newly hatched worms upon them. They

fed sparingly upon the small flowers and tender stems, but soon left the branches and could not be induced to remain long. The female shows no inclination whatever to deposit her eggs upon the last-named host-plants except as they may be found in corn fields or near by From here the young worms can easily migrate to the corn plants near at hand, and from observations already cited it is quite probable that they do so. These last observations have, furthermore, led me to suspect that the female may occasionally deposit upon all weeds or other plants indiscriminately growing in a corn field and suitable for this purpose.

CHARACTERS AND TRANSFORMATIONS.

THE EGG.

The egg is oval, the greatest diameter being very near the base. It tapers but little from the point of greatest diameter to the base, but slants much more towards the apex. The vertical diameter averages 0.375 millimetres, the horizontal and greatest diameter 0.5 millimetres. The sculpture of the eggs consists of polar ribs with cross bars, giving them a checkered-appearing surface. When first deposited the egg appears nearly a pure white, but soon turns yellowish as the growth of the embryo begins, and deepens as the latter develops. After about 25 or 30 hours that part of the embryo at the apex of the egg is noticeably darker, and between it and the center of the egg a reddish or brownish band is formed. The latter so far as can be seen extends only part way round the egg.

This band is later absorbed into the body of the worm and the darker spot at the apex is found to be the head of the developing larva. At this stage the body of the worm can be quite definitely seen through the eggshell.

The duration of the egg state varies somewhat, as will be seen hereafter, with the meteorological conditions prevailing at and immediately following the time of deposition. One lot of eggs deposited in confinement at night and followed by two very hot days began hatching within 45 hours. But of a number of lots of eggs deposited in confinement from time to time, the duration of the egg state was usually from 2½ to 3 or 3½ days. This may be considered about the normal duration of the egg state. Several lots, however, which had been deposited during unfavorable weather did not hatch until after 4 days; in a few instances a few hours over 5 days.

THE LARVA.

The newly hatched larvæ, before they have taken any food, average 1.54 millimetres in length, are slightly larger anteriorly, tapering gradually, as is shown by measurements of the diameters of a number of worms at the first, middle, and last segments, whose averages were 0.23, 0.20, and

0.14 millimetres, respectively. The general color of the body is white, with a yellowish tinge; head, black; a black or brownish shield-shaped spot on the dorsal surface of the first segment.

Soon after they begin feeding the larvæ turn darker and before the first molt are usually of a deep rose or brownish color. The piliferous tubercles are not yet very prominent. The true legs at first are slightly

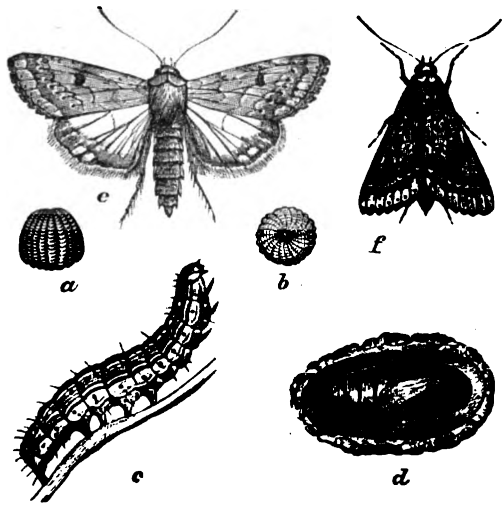

FIG. 2.—*Heliothis armigera:* *a*, egg from side; *b*, do. from top—enlarged; *c*, full-grown larva; *d*, earthen cell with contained pupa; *e*, moth with wings spread; *f*, do. at rest—natural size (after Riley).

dusky, but soon turn much darker, are hairy and provided with a small bifid claw. At first the first pair of prolegs seem to be a little less robust than the others, and hence may be slightly weaker. Obscure dark lateral patches are found on the prolegs, which at this stage are further provided with fine small hooks.

By the time of the first molt the worm has attained a length of 5.62 millimetres and is slightly larger in the middle.

After the first molt the larva is at first of a yellowish color, but again turns darker rapidly when it begins feeding. The true prolegs become much darker, and at their insertion next the body a small dusky spot, both anteriorly and posteriorly, is found. The dark lateral patches on the prolegs are also more distinct, each proleg being now provided with nine small hooks.

By the time of the second molt the larva measures 7.75 millimetres in length and is still a little wider in the middle.

Soon after the second molt the worm measures 8.75 millimetres in length. The most noticeable changes are, that the piliferous tubercles are now much more prominent; that the very small tubercles found thickly scattered all over the body first become quite discernable to the naked eye.

With the three subsequent molts there are no marked changes except in size and the distinctness in definition of the various colorings and markings of the body of the larva.

The mature worm varies in length from 31 to 36 millimetres, with diameters of about 4, 5, and 4 millimetres at anterior, middle, and posterior regions, respectively. The head of the mature Boll Worm is never darker than a light brown, or, in the darker colored worms, mahogany, but may be paler according as the specimen is a lighter colored one. The true legs are dusky or blackish, as also the spots on the prolegs. The latter are now each provided with fifteen small hooks.

The color of the body of the mature worms varies from all gradations of the darker or rose-colored specimens to those which are light-greenish with a faint rose tint or entirely light-greenish. The darker colored ones greatly predominate from about August on through the remainder of the season. The markings of the worms which are most frequently met with at this time are as follows:

Along the median line of the dorsal region is a brownish or blackish stripe containing in its center an interrupted white line. Next, the subdorsal stripe, which is lighter colored, and along which is found the first subdorsal row of piliferous tubercles. Below this is a subdorso-lateral stripe, which is usually about the same color as the dorsal one. The subdorso-lateral stripe is slightly wider at the center of each segment, and within its borders are found two more rows of piliferous tubercles. Next comes the lateral or stigmata stripe, which is usually pure white. Along this stripe are found the spiracles and one row of piliferous tubercles. Between the lateral stripe and the prolegs is a stripe, which is usually of the same color as the ventral surface, which latter is a uniform whitish. This sublateral stripe contains two rows of smaller tubercles. In many of the darker rose tinted specimens this stripe is often nearly a pure rose color, in which case the stigmatal stripe is also more or less tinted. Throughout all the stripes except the lateral and sublateral ones, and in these where they are colored other than white, are found numerous interrupted, irregular, white lines and spots. The stripes are all of a uniform width throughout, with the single exception mentioned. In the lighter colored specimens none but the dorsal and subdorso-lateral stripes can be distinguished at all, and often only the dorsal one.

The first segment is provided dorsally with a denser, calloused part irregularly shield-shaped and which is pale brown or black, according as that is the general color of the worm. In the newly hatched worm, however, it nearly always appears as a very distinct black patch. This calloused portion has a distinct median groove dividing it into two symmetrical halves, each of which bear similar markings as follows:

Four small pits in the form of a trapezoid, the posterior pair being nearest together; from each of these pits extends a fine short hair. In the center and extending each side of the median line are two deep

transverse parallel grooves. At the curved lateral regions of the shield are found slight depressions, and again one at the posterior end of the median line. The shield is further traversed by irregular lines or wrinkles, and in addition contains short white interrupted lines and spots much the same as those found in the stripes of the body. Dorsally the second and third segments each have a transverse row of four piliferous tubercles. The fourth to tenth segments, inclusive, have each four piliferous tubercles, slightly larger than those of the second and third, and are arranged in the form of a trapezoid, the anterior pair being nearest together. On the eleventh segment the four tubercles are arranged in the form of a square; on the twelfth the trapezoid is reversed, the posterior pair of tubercles being nearest together.

Laterally, the first segment is provided with a spiracle about which are two piliferous tubercles. Below there are two smaller tubercles which are usually contiguous and appear much like one tubercle from which two bristles project. The second and third segments each have two large piliferous tubercles, two slightly smaller ones and two still smaller. The fourth to eleventh segments inclusive each bear three tubercles arranged in triangular form about the spiracles with a fourth smaller one below them. The twelfth segment usually has two placed contiguously, or nearly so. Ventrally the tubercles are all small. The fourth segment bears six small tubercles arranged so as to form the arc of a circle. The fifth segment has two transverse rows of tubercles, four in each, the ones in the anterior row being wider apart than those in the posterior. The tenth, eleventh, and twelfth segments each bear a transverse row of four tubercles. All the tubercles throughout have projecting from them a short, stout hair, or bristle.

The growth of the larvæ is somewhat slower during their earlier stages than when half grown and approaching maturity.

When nearing maturity the molts occur at shorter intervals. The intervals between molts become longer later in the season or with cold and unfavorable weather. Thus in August the first molt occurred on the fifth day after hatching, the second on the tenth, the third on the fourteenth, and the fourth on pupation, seven days later. September 25 some eggs began hatching; the first molts occurred on the seventh and eighth days thereafter, the second on the fifteenth and sixteenth days; at this time the particular worms under observation made their escape and the interval of subsequent molts could not be recorded.

The length of the larval state is longer later in the season. Thus at Shreveport, Louisiana, Dr. A. R. Booth reports that during August a worm matured and was preparing to pupate after having fed 15 days; another after 18 days. At Holly Springs, Mississippi, for the same month worms matured within 18 to 20 days after hatching. For September worms hatched about the first of the month, matured in from 21 to 26 days, while larvæ hatched September 25 escaped after 18 days days and had only just molted the second time.

The first food of the worm is the eggshell from which it has just issued. No sooner is the young larva fully out of its shell than it crawls away once or twice its length, turns around, and eats the shell either entirely or but a portion of it. This done it crawls about a short time until it finds a spot suited to its taste, usually first spreading a few threads of a frail web. Under this the worm feeds on the epidermis of whatever surface it may have selected. Often they crawl but a short distance, drop themselves down by a slender thread until another surface is struck, when they crawl away as before and begin feeding.

Before the first molt the larvæ feed principally outside of the young forms and squares on whatever surface they may be when hatched. At about the time of the first molts, or soon thereafter, they begin seeking out the forms, blossoms, and squares and begin their destructive work of boring into them. It must be stated, however, that from the first a few may be found to go directly to a small form or square and either boring through the involucre and thence into the blossom or fruit, or else first crawling between the involucre and fruit and then boring into the latter. Often, too, they at first simply hide behind the involucre, eating the epidermis from the inside and boring into the fruit later. Preferring the tender growing portions of the branches, the younger worms after finding them secrete themselves in the opening clusters of leaf and flower buds and begin boring.

Their first feedings upon the leaves, whether on the upper or lower surface, are principally confined to the epidermis. About the time of the first molt they begin to eat small holes through the leaves. This is not continued long, however, as at this time the worms begin their search for the forms and squares. During the younger period the worms feed most on the reprodutive organs of young forms or such as are nearly grown and opening. Some time later, after about the second molt, they begin boring more plentifully into the larger bolls. The older worms, while feeding principally in larger bolls, do not confine themselves to them and are often found devouring a form or opening blossoms. Due to their choice of food (speaking only of the bulk) the younger worms are found mostly on the younger tender-growing portions of the cotton plant, and the more nearly grown ones on the more mature portions. For a change the full-grown worm sometimes feeds on a leaf or eats through the green stem of a newly formed branch. Stems which were .25–.30 inch in diameter and having above them a number of forms have been observed to be eaten nearly through by them. A day or two after the branch would be found wilted or nearly broken off.

The habits of the worm, as to the manner in which a boll is entered and the extent to which it feeds upon the same after it has entered, are also rather variable. The worm may pass in behind the involucre and bore into the boll from the inside, or it may choose to do so from the outside, eating through the involucre and then into the boll. The hole is usually bored from the bottom and passes towards the apex; fre-

quently, however, the hole is bored about midway of the boll and passes straight in. As the worm thus feeds on the inside of the boll it may pass straight towards the apex, devouring only the section of the fruit which it has entered and then retreat, and attack another boll, or it may bore through the partition into a second section, devouring it, or the passage of the worm may be a slanting one from the first, in which case two or three sections may be entered before retreating. The worm seldom continues until it has destroyed all of the sections of the boll, though the remaining sections are usually made worthless by the decay which arises and spreads from the injured portions.

The notion which some planters have that the worm eats in at one point on the boll and passes out at another is wrong, for if it ever does so it is certainly the exception. Occasionally, however, there are two holes in a boll similar to those which the Boll Worm makes and indeed the Boll Worm has been the culprit. Observation, however, has proven that the Boll Worm occasionally begins boring at one point, eats into it but a short distance, retreats, and begins a second hole at another point on the same boll. Sometimes, also, two worms are found attacking the same boll, which, when they have finished and left it, appears as if a worm had entered at one point and passed out at another.

It is further believed by some that the Boll Worm travels *only* at night and feeds only late in the afternoon and evening. Concerning both it must be said that the worms avoid the extremely hot sunshiny part of the day, and prefer traveling and feeding during the cooler parts; but at the same time considerable range must be allowed for the whims of the worm, and other conditions which may arise to induce the worm to go from boll to boll during mid-day and often at high temperatures. As bearing on this it may be stated that often while making morning observations in the cotton fields worms were found in bolls. Without any disturbance these branches were marked so that they could be easily found for experimental purposes in the afternoon. In the afternoon it was always found that a number of worms had gone to other bolls or even branches on the same plant. Occasionally, too, one would be found to have left the plant entirely and could not be found. The changing of plants was not often done during the day, but was oftener found to be the case with those specimens which had been marked the preceding evening and were looked for the next day. The changing from boll to boll on the same plant may be frequently observed during the day. The time of day when the worms feed most vigorously is during the cooler portions of the afternoon and evening and in the morning before the sun shines so hotly.

After the killing frosts in late October and November the worms which had not yet matured were found to feed as best they could upon the berries of *Solanum carolinense*, and possibly, if forced to, would feed upon any other available green plant found in the cotton fields. Extensive observations on this point could not be made, since the worms

were not at all plentiful. It remains to be added that the larger Heteropterous insects, mostly Metapodius, were abundant upon Solanum at this time, and that probably great numbers of the remaining immature worms fell a prey to them.

The cannibalistic habits of the Boll Worm are also of importance and must be considered here. First to be mentioned in this connection is the fact that the Boll Worm devours its larval skin as soon as molted and does so before it begins feeding on vegetable matter again. When collecting worms from the fields considerable care must be exercised to have a box or basket large enough to receive some foliage, in order that the worms may not injure and destroy each other before reaching the laboratory. In the breeding cages the Boll Worms not only attack each other, but almost any other larva placed in the arena. In a state of nature they have not been observed to deliberately attack each other except in corn, especially when the field was a small one, and great numbers of eggs are deposited and hatched on the same plant, so that an unnatural number of worms expect to feed upon the same ear of corn. The same may be said concerning the "bud," if the plant be young yet.

In several instances where such small fields of corn were found near large cotton fields, examination of the ears resulted in finding from three to six worms of various sizes in them. A day or two later when the same ears were examined some of the smaller ones were found to be badly bitten (enough to cause death), and some dead ones whose bodies gave evidence of a violent death. None of the worms had been devoured, and it seems that the warfare had been brought about by the worms intruding on each other's territory, as feeding progressed, and that nothing more was done than would maintain their positions.

THE PUPA.

A number of Boll Worms which had been fed on bolls in breeding cages matured and were placed in a fruit jar about two-thirds full of earth. The worms at once entered the earth, formed their cells, and pupated about 2 or 3 days after. The pupa is a beautiful green at first, but soon turns to a light brown or mahogany. When all the worms had pupated the earth was examined to determine something about the depth of the burrows and cells and the manner in which they were made. The earth had been recently placed in the jar and was quite loose when the worms were placed on it. The depth of the burrows varied from 2½ to 5 inches and throughout their course were partially filled with loose earth. The cells were all much larger than any part of the burrows and extended upward from the end of the same. One worm had come to the surface of the glass in making its burrow, and was observed while making its cell. The worm seemed to test carefully every part of the wall of the cell to see that all was firm. The whole surface was then thinly coated with a sticky fluid, at the same

time adding a small amount of webbing. The latter was plainly to be seen on the glass of the jar.

Some of the mature Boll Worms which had been left in the breeding cage without earth pupated unprotected on the floor of the same and later issued as moths. In another instance, however, the mature worm had been left in a newly-made breeding cage. The next morning the worm was found to have nicely webbed together the sawdust accidentally left in the corner, and had formed a neat little cell, which might almost be called a cocoon. This shows plainly that the Boll Worm is capable at least of spinning a certain amount of web for its cell, whether it always does so to so great an extent or not.

It was stated above that the worms pupated about 2 or 3 days after having entered the earth. This, however, applies only to the months of August, September, and October. Later the time is longer, as is shown by the following observations: On November 1 a mature Boll Worm from a breeding cage was taken to a cotton field and placed on solid earth, a large open tin can being placed about the worm so as to compel it to make its burrow under observation. The work of digging its burrow was begun at once, and by the next day it had disappeared below the surface. A small conical-shaped mound of loose earth was formed about and over the opening of the burrow. On November 4 two other mature Boll Worms were similarly placed in open cans, the one on solid earth, the other on earth which had been dug up and made very loose. So far as could be seen without digging the burrows were made exactly as the one just mentioned.

On November 14 all the burrows were carefully followed up with a small trowel, to determine depth, condition of the burrows and cells. The worm placed on solid earth, November 1, had proceeded as follows: Down for an inch, then slanting at about an angle of 120 degrees for 2 inches more when the cell had been made upward. The cell was about an inch and a half long, and was therefore within an inch or less of the surface. Very little webbing was noticeable along the burrow, and but little in the cell. The burrow was about 0.25 inch in diameter, larger at the distal end, and contained a small amount of loose earth along its entire length; also a plug of loose earth about 0.25 inch long at the distal end next the cell. Having been in the earth 2 weeks, I was surprised to find that the worm had not yet pupated. The burrows and cells of the other two worms were examined, but no special difference worthy of note was found. The peculiar facts in all were: (1) That the cells were all inclined and higher than the lowest part of the burrow, thus bringing the pupa above the latter; (2) that the cells were so near the surface; (3) that the larvæ were all found with their heads at the upper end of the cell, wherefore the pupæ would have been found with the anterior portion highest and resting on posterior end; (4) that they had not pupated after having been in the earth so long a time.

The duration of the pupal state as noted by Dr. Booth for August to September 2, was 10 to 11 days. At Holly Springs, Mississippi, a number of worms pupated between August 28 and 31. Some of the pupæ issued after 15 days and others not until after 27 days. Two others which had pupated September 4 and 7 issued September 20 and 30, making 16 and 22 days for the pupal state, respectively. Another worm pupated August 31. This pupa was alive, but had not issued at last observation, October 20, when it was injured and died later.

For description of pupa see Fourth Report, U. S. Entomological Commission, p. 371.

THE IMAGO.

For description of the moth see Fourth Report, U. S. Entomological Commission, p. 371.

The sexes of the Boll Worm moth can usually be readily recognized, especially if but a short time has elapsed since their issuance. After the females have deposited most of their eggs and their wings have become worn and battered the sex is less easily distinguished. The body of the female is noticeably more robust than the male; especially the abdomen, which is distended somewhat by the eggs which are being matured. The end of the abdomen is ovoid, acute, the tip not provided with so large a tuft of thick hairs as is that of the male. The abdomen of the male tapering more gradually is slightly longer, of less diameter, and more cylindrical.

When feeding or ovipositing, the flight of the moth is much slower than when flying long distances. The moth approaches a flower or gland, often steadying itself with the fore legs, in any case fluttering its wings rapidly, with antennæ in constant motion. Sometimes they alight to sip sweets, or perhaps to rest; in either case the wings are not closed down upon the body, but are partially spread and elevated, leaving bare the abdomen. If, however, the moth alights to hide, the wings are folded down closely upon the body. Much the same flight is observed in the female when ovipositing, sometimes alighting to do so, but usually only steadying herself with the fore legs. In the act of oviposition, the abdomen is bent forward sickle-shaped, bringing the apex squarely upon the surface to be deposited on. The time occupied in depositing an egg in this manner is equivalent to the time it requires to count three or four slowly. At this rate, and in the interval of flying about from plant to plant, some half dozen eggs are deposited, when the moth is seen to fly away. So far as can be determined these intervening flights are for the purpose of feeding and rest from labor.

Though the habits of the Boll Worm moth have been classed as nocturnal, and they are principally so, yet its diurnal habits are perhaps of geater importance than has hitherto been supposed. During continued daily observations on the Boll Worm in the field the moth was frequently seen flying about, and at times observed to feed. Upon closer obser-

vation it was found that on pleasant sunshiny afternoons the moths flew about quite plentifully, feeding freely during their flight. Often while standing in a patch of cowpeas, from about 3 p. m., have I observed the moths, without any previous disturbance, rise here and there, fly about the pea blossoms or the glands at the base of the young pods, sip their exudations for a few minutes at a time, and then fly away a short distance, alight to rest and hide. In the early part of the afternoon the length of their visits to the pea blossoms are short and the time of their hiding longer than later. About 5 to 6 p. m., when the sun is yet quite high, the moths begin to fly for a longer time and their hidings are of shorter duration.

My own experience with the moth has been that it feeds freely from about 4 p. m. until sundown, when the females begin depositing their eggs, feeding being apparently a minor matter at this time. The moths thus seen flying about in the afternoon are not confined to one sex, though the males predominate during the earlier period until an hour or so before sundown, when both sexes appear presumably in about equal numbers. The favorite food of the moths at daytime are the blossoms and other secreting glands of the cowpeas; they also feed freely on clover and *Helenium tenuifolium.* During the day the moth is seldom met with in the cotton fields either as feeding or by being flushed. It therefore appears that during the day the moth prefers to hide and feed upon plants some distance away from the cotton fields. During twilight and night the moths are found abundantly in corn and cotton fields, and feed almost entirely upon the exudations of the various glands found on the cotton plant.

But not only are the feeding habits of the moth partly diurnal but also those of the deposition of eggs. Though on several occasions a moth was seen depositing eggs on corn, and once on cowpeas in mid-afternoon, the habit is not one of frequent occurrence.

These diurnal habits of feeding and occasional deposition are of great importance in the consideration of the utility of lights as traps for catching the moths at night, and will be taken up more fully in that connection.

The number of eggs which a female may be capable of depositing is difficult of absolute determination, but has been shown to be much greater than was supposed. A female which had issued in confinement was placed in a breeding cage with a male which had issued the succeeding day. Five days after deposition of eggs began, and continued for 7 days. During this time 687 eggs were laid. Unfortunately, the female which was thus under observation after having died became mixed with other dead specimens on the table and hence no dissections were made with a view of determining whether any well developed eggs remained in the abdomen or whether the number of potential ova was great. A female captured August 5, and confined in a box deposited 627 eggs in one night. Another, captured August 8, and

kept in the same manner, deposited 468 in one night. Another, captured August 14, deposited 505 eggs the first night, was kept in a tin box without food during the next day and deposited 125 eggs more on the second night, making 630 in all. The first female spoken of above as having deposited her 687 eggs on seven successive nights did so as follows, beginning with the first night and continuing in order: 49, 5, 10, 436, 147, 22, 18; averaging 98 per night.

The life of the moth was probably shortened by confinement, and therefore the average number of eggs deposited each night is entirely too high for oviposition under normal conditions. The record, however, shows that a climax in egg deposition is reached after a certain period. (The possible importance of this fact is considered under the head of lights as traps for the moth.) The total number of eggs deposited by the four females above noted was 2,413, averaging 603 per moth. But the number of eggs deposited in one night by the moths captured and confined show that their period of greatest egg deposition had already been reached by them. Judging from the record of the moth whose deposition of eggs was observed from the first, it seems safe to suppose that probably each of the other moths had deposited about 50 eggs previous to being captured. This would raise the average to 653 eggs per female. But again, from dissections of the females thus observed in confinement it was found that a number of well developed eggs remained, and usually also a great number of potential ova. The average of 653 eggs per female is therefore certainly not too great and probably much too small.

What the number of eggs deposited in one night in a free state of nature are can only be approximated. As has been stated the female deposits four, five, or more eggs in succession, then flies away, feeds or rests a time, afterwards repeating the process. The interval of nondeposition is necessarily variable, though as near as can be determined about 5 to 15 minutes. How long deposition is continued during an evening is also not to be definitely stated, though it is noticeable that the moths begin to decrease greatly in numbers soon after 8 o'clock, thus approximately the time is about 2 hours. From these data it may be approximated that from about 30 to 60 eggs are normally deposited in a single night. For the nights during the period of greatest deposition, the number deposited is probably much larger.

Upon the number and distribution of the eggs upon the various parts of the host plants the following data are collated: By actual count the number of eggs found on five corn plants is as follows, in averages: per plant, 74 distributed as follows: tassel, 10; leaf sheaths, 10; leaves, 14; husks of ears, 15; silks, 25. The above count was made in a small patch of corn surrounded by cotton fields with no other corn near, wherefore the number of eggs per plant was perhaps greater than on plants in larger fields of corn. (This point will be considered more fully under corn as a protection to cotton, which see.) Of five cotton plants

the number and distribution of eggs in averages was as follows: per plant, 7; leaves, 4; involucre, 1; stem and petiole, each, 1. These are the data for plants examined at random at different times while making observations. Bearing upon the choice of the place of deposition the record of the female already spoken of as depositing in confinement is interesting, and for the whole period of deposition was as follows: on leaves, upper side, 37; under side, 110; stem, 23; petiole, 51; involucre, 4;

The eggs are deposited upon quite a number of host plants. Corn is unquestionably preferable if not too near maturity. Cotton perhaps ranks next, though they deposit freely upon cowpeas. In addition to these the moth was observed to deposit on the flower heads of *Helenium tenuifolium*, *Amarantus spinosus*, and *A. retroflexus* with *Datura stramonium*, upon which the moth feeds occasionally, *Erigeron canadense*, and a species of *Panicum*, on the doubtful list. Deposition was not actually observed on any other host plants, though presumably the moth will deposit on those plants upon which the worm is known to feed.

The food of the moth is quite diversified. During the night, so far as observed, the secretions of the various glands of cotton seem to be their main food, while during the day the same may be said of cowpeas, *Helenium tenuifolium*, and to a lesser degree of newly protruding corn tassels; occasionally, *Amarantus retroflexus*, *A spinosus*, *Datura stramonium*, and perhaps some of the grasses. There may be many other flowers, glands, possibly also fruits, which are visited, but which did not come under observation.

The regular flight of the moth is very swift and never very high. In flying some distance in a cotton field it seldom rises to the level of the tops of the cotton plants, but flies lower, darting this way and that between the plants and foliage in the rows, and in this way from row to row across the field. This manner of flight is also of importance in adjusting lights as traps for them, and is referred to its appropriate heading.

During the greater portion of the day the moths remain hid. If in corn field they are found down behind the sheath of the blades of the stalks, about two or three feet from the ground. But most of the moths hide outside of both corn and cotton fields, around the edges in the weeds, under dried grass and rubbish, or in adjoining fields of clover or cowpeas. When found hiding in these places they are usually upon or near the ground, wings folded upon the body, and so located that a dried blade of grass or other object quite completely hides them from view.

NUMBER OF BROODS AND HIBERNATION.

Observations having only begun in August, the notes taken begin with the fourth brood, which is the one which first begins to deposit freely on cotton.

The broods overlap each other mostly as a result of a difference in the rapidity of growth of many of the worms. One lot of Boll Worms obtained from eggs deposited in a breeding cage by a single female in a single night, and later hatched on the same date, were reared under the same conditions. Some of these worms matured and entered the earth for pupation, while others were yet but half or two-thirds grown. Due to such great irregularity in the length of the larval state fresh females of the fourth brood may be found along with the first to issue of the fifth brood in September. Not much work of the Boll Worm in cotton is noticed until August or early in September. From about the middle of September the moths of the fifth brood begin appearing, and continue to the last of the month, or even the first of October, after which time they are not often met with. At least a partial sixth brood begins appearing late in September and early in October, and consist principally no doubt of those individuals that have undergone their transformations rapidly. That all of the sixth brood does not appear is evident from the fact that they are fewer in number than any of the earlier broods. Hence many of the pupæ of the fifth brood of moths pass through the winter as such and form a part of the first brood in spring. The moths of the last brood appearing so irregularly, worms hatched from eggs of this brood are found in all stages as late as November 20 to December 1. At Shreveport, Louisiana, during this period Boll Worms were found on cotton which had only molted the second time and were therefore only about one-third grown.

But this irregularity in duration of certain stages of the insect is not confined to the larvæ, but to the pupæ as well. Of a number of pupæ which had been kept over from September and October one issued at Shreveport, Louisiana, December 12. Whether the moths, if there be many which issue at this time, hibernate as such or deposit their eggs at once and die soon after, has not been determined positively. If the latter be the case, the progeny will certainly be entirely lost, since no living food plants are found at this period. The Boll Worms which were yet immature at the time of the killing frost early in December were quite certainly destroyed, as nothing remained for them to feed upon. As to whether the moths hibernate, I can only say that close and continued search during December has failed to discover the moth. This may not be surprising, however, since certainly the moths which issue at so late a date, and which would therefore be likely to hibernate, are very few in number, and hence would be met with perhaps only accidentally during the winter season. Though a few moths issue at so late a time as has been mentioned, the other extreme is also met with in the pupal state. Evidence of this is the fact that several pupæ which were obtained from breeding cages late in August had not issued up to November, when they were still alive, but were accidentally injured and died.

It must be kept in mind throughout in speaking of certain stages of

the species that a majority only of that stage is referred to. It should further be remembered that these observations apply only to the northern region of "the cotton belt" and doubtless can be much enlarged upon by observations in more southern portions.

NATURAL ENEMIES.

The fact that the Boll Worm was so scarce during the past season precluded making extensive observations along this line.

Among the vertebrates only circumstantial evidence was obtained. In one instance where the dissevered wings and torn bodies of Heliothis were found under and near a large tree in a cotton field it was also found that a "butcher bird" had its nest on one of the upper branches. Another was the case of a negro tenant, who complained about the crows lighting on his corn plants in the field and eating into the end of the ears. Upon examination it was found that the corn was badly infested with Boll Worm. This alone could not serve to establish the fact that crows picked into the ears for the primary purpose of feeding on the worms. Feeding on the tender grains of corn beneath the husk quite probably an occasional small Boll Worm was eating. It is also probable that still others will be injured by the pecking into the ends of the ears. The crops and stomachs of a number of quails were examined and though they had them shot about cotton fields no Boll Worms were found in these parts of their digestive organs. Upon visiting the fields about which they had been shot no Boll Worms could be found and the negative result has therefore no great significance.

A common species of Soldier bug (*Podisus spinosus*) was found devouring a large full-grown Boll Worm. An immature capsid (near *Leptoterna*) was overlooked and left on a branch of cotton placed in a breeding cage for a female to deposit upon. Soon after deposition some of the eggs showed signs of shriveling and were supposed to be sterile. Close examination, however, led to the discovery of the destroyer, which was as yet but a pupa. The eggs being nearly empty it was evident that the pupa had punctured the eggs and sucked their contents. The same pupa was then placed on a branch of cotton with some newly-hatched Boll Worms, all of which fell victims to its beak. A common species of the robber flies (*Erax lateralis*) was also seen to catch the moth while on the wing.

No observations could be made upon ants in relation to the Boll Worm, since the latter were not abundant enough for that purpose. The ants have been watched on corn for an hour without noticing an attack upon the eggs found deposited there. They are occasionally seen to enter the holes through the husks into the ears, but I did not observe that they went in for the purpose of attacking the Boll Worms. They only sipped freely of the juices and ferments of the injured kernels of corn and the excrement of the worms. Sometimes dead worms are

found in the ends of ears into which ants have entered, but the condition of the worms plainly indicates that they had not been bitten or tormented to death. In fact, worms under similar conditions, except the absence of the ants, are often found, but from which parasites are usually bred. A nearly grown Boll Worm was placed in the path of a great army of ants, but was not caused any great inconvenience by them. Sometimes an ant would run up on the back of the worm, but the twisting, jerking, and rolling of the worm soon displaced the intruder and the worm escaped uninjured.

Of the three parasites, the one attacking the eggs (*Trichogramma pretiosa*) is most important, though there are at least three others attacking the worms. A small Chalcid* was bred in great numbers from a Boll Worm captured in the field and transferred to a breeding cage to rear. The worm had been dead for a day or two before the parasitic larvæ issued from its body. These did not form silken cocoons but pupated nakedly on the side of the glass bottle. At least two species of Tachina deposit their eggs on the backs of the worms. The one deposits a pure white egg, the other a deep brown or black one.†

Both kinds are of the usual form and size of Tachina eggs. Great difficulty has been experienced in rearing the dipterous larvæ after issuing from the dead body and I have thus far obtained no adults.

As already stated, the most important parasite is the small *Trichogramma* of the egg. The number of eggs which were found to be destroyed by this parasite was simply amazing. In small patches of corn near cotton fields it was noticed that of the many eggs found on the husks and blades but a few retained their normal color, but soon turned dark or entirely black. Of the 57 eggs taken from some 8 or 10 corn silks from this field October 18 only 7 hatched. The remainder were kept in a vial for a time, when later the parasites issued in abundance. In this instance 84 per cent of the eggs had been destroyed by the parasites. This per cent may be a little too high for the average, but judging from the large majority of eggs seen on the plants, which were black and evidently parasitized, it is certainly conservative to say that during the Fall season 75 per cent of the eggs are destroyed through its agency.

INSECT RAVAGES EASILY MISTAKEN FOR THOSE OF THE BOLL WORM.

Owing to the fact that many planters attribute all of the shed forms or bolls which show any signs of insect attack to the work of the Boll Worm, it seems advisable to treat briefly of a few other insect depredations which are not well understood by them, and whose marks upon the fallen squares may readily be mistaken by an inexperienced eye.

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*This was *Hexaplasta zigzag*, and is a parasite of *Phora* and not of *Aletia*, *Phora* being a scavenger on dead larvæ of all kinds in the South.—C. V. R.

†No black Tachinid eggs are known, and these were doubtless the eggs of *Euplectrus comstockii*.—C. V. R.

EUPHORIA MELANCHOLICA.

These beetles, together with the four species of larvæ immediately following, are perhaps of greatest importance in this connection. The first observation upon this species was made at Lamar, Mississippi. It led me to believe that the beetles did original boring into the bolls in order to reach the soft parts and their juices inside. Subsequent observations have not verified this opinion. The beetles observed at Lamar were found on a boll with their heads inserted into a small perfectly round hole about an eighth of an inch deep, or just deep enough to reach the soft parts beneath the pericarp. Few Boll Worms had been found in the field, and it seemed quite probable that the beetle had eaten out the cavities themselves. At Holly Springs, Mississippi, where the beetles were found quite plentifully in some fields, none were ever again seen under similar circumstances.

Flying about among the cotton plants during an afternoon they would be seen to alight on some boll which had been recently bored by the Boll Worm, but which had already been deserted by it. Here the beetle would sip of whatever juices there might be coming out of the injured boll. This is quite profuse at times, especially from those bolls of which the Boll Worm has but partially destroyed a certain section. From these proceeds a profuse frothing ferment, highly relished by the beetles, for occasionally two or three may be found at such bolls. When no boll with this tasteful exudate is found, they often alight on the tender-growing portions of a branch where leaf and flower buds may as yet be found but partially developed. They crowd down between these and puncture the tender and juicy peduncles, nearly always attacking those bearing flower buds. The small form supported by this peduncle dries up just as those bored by the newly hatched Boll Worm, and when dried enough to fall readily can not easily be distinguished from young Boll Worm work. With a view of determining whether the beetle ever did original boring upon cotton bolls if left to its choice, a number were placed on branches of cotton in a breeding cage, so as to be kept under observation. The results of these studies during confinement showed plainly that the beetle did its most injurious work by puncturing peduncles bearing forms or puncturing the very small bolls; in either case they were always shed. It therefore appears that if the beetle bores or eats into bolls at all, it certainly is an exceptional method of attack.

PLATYNOTA SENTANA.

The larva of this Tortricid moth is a small, green, slender, hairy worm, having a brown head, and is about half an inch long. It attacks forms and squares much the same as the young Boll Worm does. After the work is done and the worm has gone, its work can not be distinguished from young Boll-Worm ravages. These larvæ continue their

habit of feeding on forms or young bolls until about half grown, when they often migrate to the leaves, fold a portion of them together, and feed under cover. Many, however, remain with the young bolls, and reach maturity by feeding on them. They have been observed to bore half-grown bolls and destroy their contents.

CACŒCIA ROSACEANA.

This Tortricid attacks the cotton in much the same way as the preceding species, and for that reason its depredations may be mistaken for traces of the Boll Worm. The worm differs from the preceding in that the head, dorsal surface of the first segment, and the legs are black.

PRODENIA LINEATELLA.

This fleshy worm was observed entering into nearly grown bolls and feeding on their contents. Its ravages are exactly like those of a nearly grown Boll Worm, and the two can not be distinguished.

NOCTUID (undetermined).

A cutworm, looking much like *Agrotis c–nigrum*, was found in a large breeding cage which had been placed over some cotton plants in the field. When placed over the plants, none of the forms or bolls had been injured, and no Boll Worms were found on the plants. Some time later several large bolls had been bored, and this worm was the only one which could be found in the cage. The evidence is therefore only circumstantial.

PLANT LICE.

(*Aphis gossypii* and *Aphis* sp.)

These small, greenish, mostly wingless, insects were especially abundant during the past season. Earlier in the season they are found principally on the leaves and younger growing portions of the branches, but frequently also on the young bolls between them and the involucre. Later in the season they are found most abundantly in the last-named localities, and in such great numbers on a single form or young boll that the latter soon fall off as a result of their puncturings.

In many cases the fruit thus injured simply dries and adheres to the branch. This fact often serves to distinguish it from Boll Worm work. Even when this is not the case their work is readily distinguished in that the form or square contains numerous small punctures.

THRIPIDÆ.

These small brownish insects during August were found in great numbers in the forming blossoms of the cotton plant. The feeding of these insects causes the form to drop soon after the blossom falls, if

not before. Such forms often present small black spots looking like small borings, but which are so numerous that they need not be confused with young Boll-Worm ravages. It must be noted that these signs of mechanical injury are not to be attributed to the Thrips. The shedding of these bolls is probably due to the fact that the work of the Thrips on the essential organs prevents fertilization. This insures the dropping of the fruit.

Many other species of the suborder Heteroptera probably puncture the pericarp of the very young bolls or their peduncles, in either case causing the shedding of the fruit. Careful examination will show that the injury is a puncture and should not be mistaken.

Neither of the first four species mentioned are numerous enough to cause alarm or extended damage, and are only mentioned to show that there is a certain small per cent of injury easily attributed to the Boll Worm which does not justly belong to that species.

REMEDIES.

TOPPING OF COTTON AND ROTATION OF CROPS.

These have both been justly pronounced inefficient as a means of fighting the Boll Worm (see Fourth Report U. S. Entomological Commission). It may be stated, however, that numerous interviews with farmers verified the opinion that topping did no harm, and that if "you could strike it right" it was an advantage. Experimentation is first necessary to show that it is practical and profitable to practice topping of cotton as an additional means of cultivation and the proper time to do so determined. When this is done it will depend largely upon whether that time falls within the period of greatest deposition by the moths. If so, no doubt some additional benefit will be derived by the destruction of the eggs deposited on the parts cut away in topping. But since the moth has been found to have such a wide range of deposition and the portion cut off in topping is so small in proportion to the whole surface of the plant exposed and suitable for deposition, it is not to be recommended to incur the expense of topping when nothing more is to be accomplished than the destruction of the few eggs which are likely to be found on the parts cut away. The rotation of crops can be of no avail against the insect, since it feeds equally well upon the corn or cowpeas, which are most likely to be rotated with the cotton.

FALL PLOWING.

This is to be urged for several reasons. It has been my experience, that where the cells of the Boll Worm pupæ are broken up and placed in loose, moist earth, which is allowed to be moist continuously and possibly to excess, that the pupæ die in a majority of cases even without freezing. It therefore appears that actual contact of the pupa

with the cold moist earth sooner or later may cause its death. From this fact and the long continuous rainy season of the winter here it seems probable that great numbers of the pupæ will be destroyed if the soil be plowed late in December, so as to allow the loose earth to become well drenched by the almost continuous January rains. Subsequent rains will keep it quite wet, often perhaps, to excess. The pupal cells having been broken up, the wet earth directly affects the wellbeing of the pupæ. Even though the exposure to moisture alone should not prove entirely efficient, a light frost or the sudden cold wave changes of the atmosphere would greatly aid in the work of destruction. Certain it is, that a heavy frost occurring when the pupæ are in such condition would destroy all thus exposed. For this reason if the soil could be plowed in November so that the first black frost of the winter season could be utilized in killing exposed pupæ, great benefit would certainly be derived.

CORN AS PROTECTION TO COTTON.

Cornfields planted in July or August were always found to be badly infested with worms. Especially was this the case where the fields were small and near cotton fields. At the same time corn fields no larger but greater distances away from cotton fields were less infested and the cotton more so. As has previously been noted, this is explained by the fact that the moths feed mostly on cotton at night, but leave it to deposit on corn if found suitable and near by. Even late spring planting was found suitable for deposition in August, though maturing rapidly and having nearly grown worms in the ears. Especially suggestive were the observations made in cotton fields where a poor stand had been obtained and where corn had been planted in the "skips." In all cases the moths deposited freely upon the corn, though it was fast reaching maturity. Several of these cotton fields were carefully examined. The most extended search for worms revealed very few indeed, and the only possible conclusion to be arrived at was on the whole that the damage to the cotton was not so great as in those fields without the corn distributed through them. It is therefore evident that by the proper management of the planting of corn the latter could be made to answer as a great protection to the cotton against Boll Worm ravages. This management must consist in arranging the crops on the plantation so that green corn suitable for egg deposition shall be kept near or in the cotton fields in range of the moths.

It must be stated, however, that the corn, which is intended to act as a trap for the deposition of the eggs, and hence of the worms as soon as hatched, must be planted with a view of being cut as fodder as soon as a sufficient number of worms are found in the plants and before the worms begin maturing. From this it follows that the corn, which is to be allowed to mature and produce corn must be planted further away from the cotton fields in order that it may become infested as little as

possible. The importance of this will be appreciated when it is remembered that all the worms which mature on this corn and produce moths will furnish an additional supply to infest cotton and at the same time reduce the number trapped by the corn planted for that purpose. The corn cut for fodder should be disposed of in such a way as to insure the destruction of the worms found in the plants when cut. Each planting of corn which is to act as a trap should be planted soon enough to be in good condition for deposition as each brood of moths makes its appearance. This would require about three plantings for the northern portions of the cotton belt, and probably four in the southern.

The three plantings should occur about the first days of June, July, and August, respectively, and be cut whenever the worms are nearing maturity, to be sure to prevent their escape. By this method the least possible number of worms reach maturity. This consequently reduces their ravages on cotton later in the season to a minimum. This minimum is the most that can be hoped for, no matter what may be the remedial or preventive measures resorted to. This method would furnish a great source of fodder, and would tend to diversify Southern agriculture, a result greatly to be desired.

LIGHTS FOR ATTRACTING THE MOTHS.

Most of the experiments with lights for trapping the moths have proven unsatisfactory so far as economic results are concerned, but have been suggestive in that they have clearly marked out what will be necessary to make the use of lights more efficient.

While at Shreveport, Louisiana, in company with Dr. A. R. Booth, two kinds of patented lamps were taken into a large field of cotton to test their relative values and also to determine if possible the ease with which the moth could be attracted to lights. The lamps were lighted at 6:30 p. m. Quite a number of moths were seen flying about in the field as we passed through it, but up to half an hour after sundown but few insects of any kind were attracted. From that time until 8 to 9 p. m. insects of nearly every description were captured, but no Boll Worm moths. Sometimes a moth would be seen to approach the lamps but was more interested in feeding and depositing, always passing by or around without apparently noticing the lamps.

The lamps had been placed on pedestals high enough to bring them above the level of the top of the cotton plants, hoping thereby to attract moths from greater distances. In the mean time it was noted that the moth seldom attained to such a height during her flights about the cotton plants. Accordingly, on the evening of August 8, the same lamps were taken into the field, but placed so as to meet the habits of flight of the moth. This placed them at least on a level or a little below the plane of the top of the cotton plants. It was found that more moths approached and came nearer the lamp, and one was caught. In most cases, judging from the flight and actions of the moths, the lamps

were simply met with in their regular flight through the field for the evening, and that their course had not been materially influenced by the lights. Despite this fact, it was evident that the probabilities of trapping the moths at this height were increased. To vary the experiment, the lamp was carried through the field at about the height just mentioned, and one person walked along on each side some distance from the lamps so as to disturb the moths in that vicinity. In this way still more of the moths came near the lamps, and another one was caught. This is impractical, however, since the expense of labor is too great, at least until some means of making the lights more efficient is effected.

One of the lamps was provided with a shield constructed so that it would revolve with the wind, and thus prevent the lights from being blown out. This is entirely wrong, since the moth usually flies with the wind, in which case the light is of course shut off from view entirely. This defect renders the lamp entirely worthless for the end desired. In our experiments this shield was held or made stationary, and hence the defect did not enter or vary the significance of the results.

At Holly Springs, Mississippi, lamps were placed in cotton fields at various times during August. Some consisted merely of beer bottles filled with kerosene and a piece of unraveled cotton rope for a wick, and others of more powerful lamps. In all cases the lamps were placed in pans containing an inch or so of water, with a little oil on the surface, the whole being placed on a supporting pole or pedestal. The beer-bottle lamps burned satisfactorily, produced a good light, and attracted insects of nearly every order and kind except the Boll Worm moth, though these had been seen flying about in the field late in the afternoon.

On the night of September 9 these lamps were again taken into a cotton field having a small patch of corn near by; also a large patch of weeds, principally sneeze weed (*Helenium tenuifolium*). A lamp was placed in each at about the level of the tops of the plants, except the one in corn which was placed on about the same level as the ears on the plants. By 5 o'clock the moths were seen flying plentifully and ovipositing freely. The lamps were lighted at 6:15 o'clock. No insects of any kind were attracted until 7 o'clock, when moths of all kinds began flying near the lamps. By 7:15 a Boll Worm moth had been caught at the lamp in corn. At 7:25 at the lamp in cotton a Boll Worm moth flew near the lamp, alighted on the pedestal and rested. From here it flew up to a small boll in the direct light of the lamp, deposited an egg and flew off. From this time on many Ichneumonids and other Hymenoptera, as also great numbers of Microlepidoptera were caught. At 7:40 a Boll Worm moth was seen to fly through the flame of the lamp but was not captured. In corn at 7:50 a moth flew about the lamp and alighted on a blade of corn less than 2 feet away. For this act of defiance it was introduced to the cyanide bottle. Not many

moths were seen between 8 and 9 o'clock but the lamps were left burning all night to determine what would be the nature of the catch by the next morning. At this time the catch was examined and the results are tabulated below. For convenience the lamps in *Helenium*, corn, and cotton will be numbered 1, 2, and 3, respectively.

TABLE VII.

Hymenoptera.

	Ichneumonidæ.	Miscellaneous.	Total.
1...............	10	4	14
2...............	9	3	12
3...............	12	2	14
Total for all........................			40

Lepidoptera.

Lamp.	Agrotis.	Heliothis.	Spilosoma.	Miscellaneous Noctuids.	Geometridæ.	Pyralidæ.	Pterophoridæ.	Miscellaneous.	Total
1......	....	....	....	17	15	....	....	300	332
2......	2	1	....	1	30	....	27	300	361
3......	1	....	1	....	25	20	26	250	323
Total for all									1,016

Diptera.

Lamp.	Tipulidæ.	Miscellaneous.	Total.
1........	8	25	33
2........	40	10	50
3........	....	75	75
Total for all			158

Coleoptera.

Lamp.	Epicauta.	Scarabæidæ.	Elateridæ.	Staphylinidæ.	Carabidæ.	Miscellaneous.	Total.
1........	....	2	2	25	8	25	62
2........	7	....	....	....	2	50	59
3........	2	1	....	....	6	....	9
Total for all							130

Hemiptera.

Lamp.	Homoptera.	Heteroptera.	Total.
1........	200	100	300
2........	200	100	300
3........	200	150	350
Total for all			950

TABLE VII—Continued.

Neuroptera.

Lamp.	Chrysopa.	Total.
1........	1	1
2........	1	1
3........	....	....
Total for all		2

Orthoptera.

Lamp.	Mantis.	Œcanthus.	Locustidæ.	Total.
1........	1	2	2	5
2........	1	2	....	3
3........	2	....	....	2
Total for all				10

The above results show that the direct benefit to cotton plants, so far as known, is very small. At the same time such beneficial insects as the Ichneumonids, predaceous beetles, and the Praying Mantis aredestroyed, and if trapping be systematically followed up the loss may indeed be considered greater than the gain.

These experiments led to the belief that the lights used were not brilliant enough for the intended purpose. Accordingly, an electric lamp was rented. The lamp is provided with a round burner and the flame produced is about 5 inches in circumference. When the chimney is placed over the flame the lamp is said to give a light equal to 100 candles. Experiments with this lamp in connection with the others were continued in the cotton fields during September. On the evening of the 13th both kinds were placed out. The night proved to be a damp cold one, and the dew fell early in the evening. As a result no Boll Worm moths and but few insects of any kind were trapped. Of this small number the parasitic Hymenoptera and predaceous beetles were greatly in the majority. The insects caught were such as are easily attracted to lights, and were quite equally distributed between the three lamps (two beer-bottle ones and the other the electric lamp). A rainy season began at this time and continued so that no further experiments with lamps could be made until October 4. At this time the electric lamp was placed in a cotton field to determine what would be the nature of the catch. Heliothids had been seen flying about in the evening while making some other observations, but none were captured by the lamp at night. The other insects trapped were about the same in kind as those already tabulated for September 9, only that the quantity captured by the electric lamp was about equal to that of all three of the others, and it had only been left burning until 10 o'clock.

October 20 the lamps were again placed out, this time one in a patch of cowpeas and the other some distance away in a small patch of corn which had been planted in July. During the day Boll Worm moths

were seen hiding behind the sheaths of the corn blades, while a number were also seen flying about the cowpeas. The one in the cowpeas was a beer-bottle lamp and placed about the height of the plants. The one in the corn was the electric lamp, and was placed about the height of the ears of corn. They were lighted at 6 p. m. At this time a few of the females were depositing on corn. At 7 o'clock some were seen to fly by the lamp but were not trapped. The parasitic Hymenoptera and smaller Lepidoptera had been caught in great abundance at both lamps. Returning at 10 o'clock to further examine the catch of the lamps, they were found to have been stolen and no further notes could be taken. The moths at this time were not very abundant and doubtless were but a portion of the last brood of the season. The moths seen flying by the electric lamp were near enough to have been stopped had the lamp been provided with long projecting wings and a larger pan to receive the moths as they fell. No Heliothids were observed at the beer-bottle lamp.

These light experiments, as will be seen from the record, were begun at the time that the midsummer brood was issuing abundantly, and hence also during the period of greatest egg deposition a little later. During this period, as has been stated, the provoking observation was made of seeing the female near the lights, deposit an egg in plain view, fly away and continue her work. It is evident, therefore, that the female is not easily diverted from the work of depositing eggs by the ordinary lights used. Later, when the experiments show that a few moths were trapped, it is also true that the period of greatest deposition had passed, and that, though dissections showed that a few eggs still remained together with a number of potential ova, the females had passed their prime. As bearing on this the following may be drawn from the observations of Dr. Booth : The insect contents of a globe of a 2,000 candle power arc light were examined continuously from September 3 to 13, inclusive. An average of 40 Heliothids were found for each night. Of these 1 in 6 or 8 were females, containing on an average from 30 to 40 eggs in the oviducts. The lamp tender reported that after September 26 no more moths were caught.

The fact that the moth was frequently seen to fly near the light, often as near as 2 or 3 feet, suggests that the lamps to be efficient not only must be brilliant, but must also have some wide and extensive wings extending from it in such a way as not to throw a shadow and to arrest, temporarily at least, the flight of the moth passing near by. If now the large pan and the lamp be provided with an additional inducement in the way of some strong smelling sweets, the moth thus arrested in its flight and its attention diverted from its evening work, if not falling into the pan, may be attracted a second time and be captured.

Unless it is found that the earlier broods are more easily attracted to lights it is questionable whether the inefficient lights so commonly used

by planters are to be at all recommended if nothing more is to be accomplished than the trapping of the Boll Worm moth, and for the following reasons: (1) But a small per cent are caught; (2) of these the great majority are males; (3) while some females are caught before having deposited many eggs, the greater per cent have passed their prime; (4) beneficial insects being more easily trapped are destroyed in too great numbers in proportion to the benefit derived from the destruction of obnoxious insects to warrant such inefficient warfare. These may all be included in the one general reason that the lights are only strong enough to readily attract beneficial insects but are powerless to attract the obnoxious insects desired until its most important work (deposition of eggs) has almost been completed.

POISONED SWEETS.

No field experiments were made with poisoned sweets, but a number were made with moths in the laboratory. The mixture was composed of 1 part of white arsenic dissolved in 20 parts boiling water; 4 parts of this solution were added to 3 parts of ordinary table sirup. The mixture was placed in a watch glass under a bell jar or sprayed upon cotton branches in a breeding cage. When the moths were placed in they always soon found the sweets and sipped of them. The result of all the experiments showed that the moths readily partook of the sweetened liquids. Those having sipped of the poisoned solutions died, on an average, within 30 minutes; the shortest time being 15, the longest 45 minutes. Experiments were also made upon a few other insects, mostly such as were considered beneficial. They were placed in the cages just as the moths had been and were found to partake of the sweets quite as readily and died as certainly. Thus in field experiments doubtless many beneficial insects will also be destroyed by the extensive use of the poisoned sweets.

The moths kept in cages for experimental purposes were fed by spraying unpoisoned solutions of the sweets upon the cotton branches. The moths fed readily and lived usually from 5 to 8 days.

The poisoned sweets used in the experiments in the laboratory contained no liquids which could liberate a strong odor such as is necessary in field experiments. These may be added in the form of beer or vinegar or perhaps any other liquid having similar properties.

It was demonstrated by the experiments in the laboratory that newly issued and old moths were alike easily induced to feed on the poisoned drops of sweets sprayed on the branches in the cages. It may therefore follow that if these poisoned liquids can be properly applied to the plants upon which the moths feed freely both at night and during the day, that females may be readily attracted to feed, and hence killed, during their entire period of deposition. It therefore appears probable that if some practical means is employed to apply these poisoned sweets properly and abundantly as food for attracting the moths that such

method of warfare against the adults will prove more efficient than any other alternative yet resorted to against them. It is evident, however, that to be most efficient, the poisoned sweets must be applied from the time when the moths begin feeding freely, and in such a way that they may meet with them readily in their flights about their food plants. The first will be accomplished if applied as early as 4 o'clock in the afternoon, in which case the poisoned liquids would also be exposed to their visits during the evening and night. The second can be attained by spraying the poisoned liquid upon the food plants. For those moths feeding during the day this must be applied principally to cow peas, for those feeding at night upon cotton.

The practicability of this method is yet somewhat questionable since probably one application of the poisoned liquids would be efficient only for a few days. It may further be questioned in that, as has been noted, the moths of any given brood issue quite scatteringly. At the same time it may be that applications of the poisoned sweets at intervals of 3 or 4 days will prove to be as practical as arranging for, and attending to, *light trapping* properly. My own efforts to experiment fully along this line were rather frustrated by rainy weather during September. This made experiments difficult and more or less indecisive.

The possible utility of combining poisoned sweets with lights has already been noted. The fact that females are readily attracted by sweets before many eggs have been deposited by her may become a sufficient additional inducement to entice those flying so near the lamps to linger a few moments longer and probably result in her capture. With these probabilities in mind it is to be hoped that the approaching season may be more propitious for experimental work and the Boll Worm more abundant.

PYRETHRUM.

Experiments with the dry powder.—The first of the following series of experiments with pyrethrum were made upon infested corn. The patch of corn was about two rods square and located near the center of the town (Holly Springs, Mississippi). It was a second planting and was only knee high at this time, August 19. The middle rows of the patch were selected and one row for each experiment taken. The powder was dusted from above down into the bud of the corn by means of a small cheese-cloth sack, double thickness.

Experiment 1.

August 19, 2:30 p. m. Mixture, equal parts lime dust and pyrethrum. The plants in the row by actual count contained 43 worms of various sizes.

Result.—Soon after dusting a few acted uneasily, began to crawl, and finally dropping to the ground, hid in the loose earth. This note applies more or less to all the experiments made with the powders. August 20, 10 a. m., 17 worms alive and feeding, 10 dead, 16 not present. In percentages this is 39.5, 23.3, 37.2, respectively. The living worms were mostly nearly mature ones which had penetrated far into the center of the bud and may not all have come in contact with the powder. The dead

ones were mostly composed of half or two-thirds grown worms. These notes again apply equally well to nearly all the other experiments with the powder. The following experiments will therefore be given more concisely.

Experiment 2.

August 19, 3 p. m. Mixture, 2 parts lime dust, 1 part pyrethrum. Number of worms in plants, 43.

Result.—August 20, 11:30 a. m., 20 living, 10 dead, 13 not present, or 46.5, 23.3, 30.2 per cent, respectively.

Experiment 3.

August 19, 3:30 p. m. Mixture pyrethrum full strength. Number of worms 54.

Result.—August 20, 12 m., 25 living, 8 dead, 21 not present, or 46.3, 14.8, 38.9 per cent, respectively.

Experiment 4.

August 19, 4 p. m. Mixture equal parts lime and pyrethrum. Worms not counted.

Result.—August 20, 2 p. m., 19 living, 12 dead, or 61.3 and 38.7 per cent, respectively.

Experiment 5.

August 19, 4:30 p. m. Mixture 2 parts lime, 1 part pyrethrum. Worms not counted.

Result.—August 20, 2:30 p. m., 26 living, 8 dead, or 76. 5 and 23.5 per cent, respectively.

Experiment 6.

August 19, 5 p m. Full strength pyrethrum. Worms not counted and only a part of the row dusted.

Result.—August 20, 3 p. m., 5 living, 6 dead, or 45.5 and 54.5 per cent, respectively.

The dead worms of experiments 1 to 6 were kept, for raising any possible parasites, until September 3, when they were found to be perfectly dry and were thrown away. No parasites had issued from them.

As checks on experiments 1 to 6 it may be stated that in examining the rows carefully to count the actual number of worms in the plants no dead worms were found. Numerous other observations upon corn of a similar age, and which had not been dusted, verified the one made while counting the worms.

The first 6 experiments and their results may be tabulated for convenience as follows:

Table VIII.

Experiment.	Substance used.	Living.	Dead.	Absent.	Probable benefit.
1........	Lime and pyrethrum, equal parts.....	39. 5	23. 3	37. 2	60. 5
2........	Lime 2 parts, pyrethrum 1 part........	46. 5	23. 3	30. 2	53. 5
3........	Pyrethrum, full strength...............	46. 3	14. 8	38. 9	53. 7
4........	Same as experiment 1..................	61. 3	38. 7	....	38. 7
5........	Same as experiment 2..................	76. 5	23. 5	....	23. 5
6........	Same as experiment 3	45. 5	54. 5	....	54. 5
	Averages	52. 6	29. 7	17. 7	47. 4

Experiment 7.

August 20, 10:45 a. m. Dusted the 17 living nearly-grown worms of experiment 1 with full strength pyrethrum, and placed them in a closed mailing box without food.

Record—11 a. m., some are beginning to be restless; 12:30 p. m., all are quiet; 1:45 p. m., one almost dead, others jump when touched; 4:20, p. m., one dead, others as before.

August 21, 11:30 a. m. Somehave become quite active again, and as a result 4 were bitten, 3 are dead, 6 others alive and active, while the rest were probably eaten. The active ones were placed in a breeding cage, and provided with branches of cotton having leaves and bolls. Some died later and a few matured.

Experiment 8.

August 30, 4:30 p. m. Eighteen of the living worms from experiments 4, 5, and 6 were well dusted with lime. Nine were placed in each of two closed mailing boxes. This experiment was for the purpose of having a check on any possible effect of the air-slacked lime on the worms.

August 21, 11:45 a. m. In one box two were injured and died. The rest alive and active. In the other box all are well and active. Both lots were then placed on branches of cotton in breeding cages. All began feeding; a few died later, but most of them matured.

Experiment 9.

September 11. Boll Worm in a boll with posterior segments protruding. Dusted this with full strength pyrethrum at 9:15 a. m.; no immediate effect was noticeable; 11:30 a. m.; worm has turned round; head almost protruding; not feeding; 3 a. m., has turned round now to position same as when dusted, and is feeding. With a pair of forceps placed some pyrethrum powder on the body of the worm in the hole. Did not effect the worm noticeably for five to ten minutes.

September 12, 8:30 a. m. Has left the boll and is in the upper corner of the cage still alive and active.

September 13, 8 a. m. Has returned to the boll it had left, and is feeding. Dusted the protruding portion with pyrethrum. In the afternoon the worm was found crawling about in the cage, but appeared to be full grown and searching for a place to pupate. Placed back on the branch again.

September 14. Worm still on the boll and is active, but not feeding. Particles of pyrethrum are found adhering to the body. The anus is swollen and inflamed, producing a watery exudate. This may be due to the effect of the pyrethrum, for this is the portion of the body which was usually protruding from the hole in the boll and received most of the dusting. The worm was placed in a partially opened form.

September 15. Has eaten the form almost entirely.

September 16. Crawling about in cage. Placed on a branch.

September 17. Crawling about in cage. Has shortened some and is preparing to pupate. Placed in a tin can with earth to allow it to do so. Pupated September 21. Pupa still alive October 3, when it was placed in alcohol as a specimen.

In one instance, when a worm had been experimented with in a similar way to Experiment 9, the worm went down to corner of the cage (which was a newly made one), webbed together the loose sawdust found there, and pupated in the cell thus formed.

Experiment 10.

September 20, 5:30 p. m. Marked five bolls in which Boll Worms were feeding and a portion of the body protruding. At 5:40 dusted profusely with pyrethrum, full strength.

6 p. m. The first worm ceased feeding and left; can not be found. The second was entirely in boll, but came out and is twisting about uneasily; finally it fell to the ground in convulsions, tumbling over on its back as if to scrub off the powder. The third ceased feeding. The fourth was a young worm and is not to be found. The fifth still feeding.

6:15. The second is still in convulsions and can not crawl well; it is one about two-thirds grown. The third has fallen to the ground, but is crawling into loose earth. The fifth continues feeding. The last two are nearly grown worms, and doubtless will take some time to become badly paralyzed. At 6:30, while making other observations, it became dark, and could not find the worms again.

A number of individual experiments with grown worms, both in the laboratory and open air, were made. The worms were well dusted with full-strength pyrethrum and were allowed their pleasure as to their abode afterwards. They always crawled into the loose earth as soon as possible, and as long as they were observed showed signs of recovery. Other experiments similar to Experiment 9 are omitted because their results were practically the same in all cases.

DECOCTIONS OF PYRETHRUM.

Seven pints of rain water were brought to boiling in an open pan; 12 grains of pyrethrum were then stirred in and boiled for 15 minutes. The whole was then strained so as to get out most of the powder. This decoction was made on the afternoon of September 19, but owing to a threatening rain was kept in sealed Mason jars until the next day, when the decoction was sprayed on bolls containing Boll Worms. The following strengths were used: Full, two-thirds, and half.

EXPERIMENT 15.

September 20. The bolls with worms in had all been found and marked during the forenoon. The day was warm and sunshiny. In the afternoon it was found that one of the worms had changed bolls since morning observation. At 2:40 p. m. full strength of the decoction was sprayed on each of six bolls containing Boll Worms. Four of the six were not in bolls, but between them and their involucres. The greater portion of the plants surrounding the boll was also sprayed.

2:50. No uneasiness manifested by any.

3:15. Five as before; one half-grown worm has moved and can not be found.

3:45. No change; has not affected the worms yet.

4:10. None feeding; no change.

5:00. One feeding; others as before.

5:50. None feeding.

September 21. Two worms still in place; one feeding, the other just molted; two others finished the bolls in which they were found and have disappeared; the other one is in boll in laboratory.

September 23. All have gone but one; this one went to another boll, fed, and has just molted; an hour later it was found devouring molted skin.

EXPERIMENT 16.

September 20. Equal parts decoction and rain water. At 3 o'clock sprayed five bolls, each containing a Boll Worm. Four were not feeding, but resting between boll and involucre; the other was in boll feeding. None had changed position since morning observation.

3:25. One seems to be a little uneasy; others manifest no anxiety.

3:42. The one in boll has turned around and is poking its head out of the bolls; another has moved and gone into a blossom; the others same as before.

4:10. One is feeding; all the others quiet and not feeding.

5:00. One feeding; others no change.

5:50. None feeding.

September 21. Four still in place, all feeding; the other has left the plant.

September 23. One still in place, but has about destroyed its boll. The others have done so and are gone.

The record of the experiment with two parts decoction and one part rain water is omitted because of the similarity of results to those of Experiment 16.

Checks on Experiments 15 and 16.

September 20. At first three, but later five more worms were marked as checks.

2:30. One entirely in boll, feeding; another, nearly mature, resting and not feeding; a third, very young one, is feeding.

5:00. Checks all in place feeding.

5:50. All but very young one feeding. Made a search for more worms; found five, all of which are in bolls feeding.

September 21. One still in boll, but not feeding.

The small worm has bored through a form and is feeding. The nearly matured worm has destroyed its boll and has gone away.

The result of all the experiments with pyrethrum is, on the whole, negative. Before treating more fully of the results of the experiments it must be stated that the corn plants, cotton bolls, and Boll Worms were more thickly and thoroughly dusted or sprayed than it would have been possible to do by dry method of application which would be inexpensive enough to be practical. There is a special difficulty in the case of cotton. At the time when the powder would be most efficient, that is, when the worms are yet less than half grown, they are found principally at work in forming blossoms and very young bolls. In these the involucre so completely and effectually inclose the portions in which the worms are at work that it is practically impossible to reach them. It is well known that the young form or boll is sensitive to excessive rains, and their involucres, it seems, are to a great extent a provision of nature to protect the tender young bolls from such injury. To whatever extent this may be the case, it is certain that their involucres make it exceedingly difficult to reach the forms and bolls beneath them by any of the methods of spraying, and therefore also to all decoctions or solutions of whatever kind.

Upon corn before it has tasseled the powder may be used with greater success, as will be seen from a study of Experiments 1 to 6. From these we find that a certain benefit of about 30 per cent. is obtained, with a possible benefit of about 47 per cent. This last is too high, however, as some of the worms which leave do so only temporarily and to recover, after which they return. We also find that the young worms are much more susceptible, or at any rate less able to resist the effect of the pyrethrum. Consequently of the worms killed, the great majority were half or less than half grown. From the behavior of the grown or nearly

mature worms in all the experiments, it is evident that they strongly resist the effects of the powder, and if ample opportunity is given to escape to the ground or loose earth, may often entirely overcome its influence and recover. Whether on corn or cotton, it must be admitted that the protection is only temporary. This is shown by the fact that in some of the experiments undisturbed individuals entered bolls with impunity soon after dusting and after the first worm had retreated, or even the same worm going back and feeding upon the boll from which it had been driven, presumably, by the pyrethrum.

As has been noted, there is a certain benefit derived from the application of the powder to young corn before tasseling. It is just to consider that the pyrethrum was at a disadvantage, in that it was not applied early enough to catch the worms before they had become so nearly grown or had entered far into the bud. If it had been applied earlier a much greater per cent of the worms then present would doubtless have been destroyed. Such being the case, the use of pyrethrum may prove to be a decided advantage in coöperation with the plan of planting corn as traps for egg deposition, and hence the worms when these are hatched. This can be done by thoroughly applying pyrethrum of about one-half or third dilution with lime to the corn plants at a time when the worms are found to be about half grown. By doing this the time of cutting out corn to destroy the worms it contains will be delayed for a time longer, and hence also be exposed to the depositions of the moth for a greater period. Experiments in this direction will be taken up extensively this season.

The powder being thus limited in its efficacy, especially on cotton, it is not surprising that decoctions of the powder prove to be even less effective. As will be noted from the experiments with the decoctions when compared with the record of the checks upon the same, little more was accomplished than to temporarily arrest the feeding of the worms. It is true some of the worms changed bolls during the afternoon, and others which were in bolls came out, but it must also be noted that the same action was taken by other worms which were under observation and which had not been sprayed. There is some question, therefore, that the decoction was directly accountable for the action of the worms upon which it was sprayed.

This doubt is further increased from the fact that it was often noted in worms which had been marked for observation that they very frequently changed bolls or even plants during midday or afternoon.

OTHER VEGETABLE INSECTICIDES.

The work upon vegetable insecticides was assigned almost entirely to Prof. Jerome McNeill, Fayetteville, Arkansas. He has been as unfortunate as myself in being unable to obtain plenty of Boll Worms to experiment with. Progress was further impeded by unpropitious weather. For this reason the greater portion of the time was occupied in collecting

such roots, plants, flowers, and fruits as might, upon experimentation, prove to have insecticidal properties. This was undertaken with a view of discovering if possible some product easily grown in the infested regions through the cultivation of which it might be possible to provide for an insecticide which would be cheap and accessible to all. From these various collections Professor McNeill has made numerous extracts, emulsions, and decoctions, some of which he informs me are quite promising, and which are on hand to experiment with when opportunity offers. As this part of the work has, therefore, not been completed for the reasons stated, I shall at present give only a summary of Professor McNeill's letters and report of progress during the past season.

(1) Alcoholic extracts and decoctions have thus far been, on the whole, unsatisfactory.

(2) Extracts and extract emulsions of the various vegetables or parts thereof seem to be promising. Of these kerosene, kerosene ether, gasoline and benzine extracts, and emulsions of pyrethrum are perhaps most important.

(3) Of the plants experimented with, *Lobelia syphilitica*, *L. cardinalis*, probably *L. inflata*, and *Arisæma triphyllum* are among the more important as giving promise of good results. They have been shown to possess insecticide properties, but to what extent and how best utilized remains an open question.

(4) An exceedingly dilute solution of potassium cyanide is an efficient insecticide, but its effects on the cotton plants has not yet been determined.

METEOROLOGICAL CONSIDERATIONS.

Of these rain, humidity, and temperature are the principal phenomena to consider. What relation these may have to the various stages of the transformations of *Heliothis*, the following tabulated data may serve to indicate. The averages of humidity and temperature are given for the entire period covered by each example:

TABLE IX.

EGG.

When deposited.	When hatched.	Duration.	Rain, number of days.	Temperature.		Humidity.	
				Max.	Min.	Max.	Min.
				°	°	°	°
Night, Aug. 5–6	Aug. 10, 10 a. m	3½	3	93	74	88	56
Night, Aug. 8–9	Aug. 10, evening	2	0	94	73	87	63
Night, Aug. 14–16	Aug. 18, 9 a. m	3½	1	84	72	(*)	(*)
Night, Aug. 15–16	Aug. 18, 9 a. m	2½	0	84	72	(*)	(*)
Night, Sept. 19–20	Sept. 24, evening	5	5	79	67	(*)	(*)
Night, Sept. 20–21	Sept. 25, morning	4½	5	78	64	(*)	(*)
Night, Sept. 21–22	Sept. 25, morning	3½	4	77	67	(*)	(*)

* Data for humidity at Holly Springs, Miss., could not be obtained. The first two are from Shreveport, La., where eggs were under observation.

TABLE IX—Continued.

LARVA.

When hatched.	When matured.	Duration.	Rain, number of days.	Temperature.		Humidity.	
				Max.	Min.	Max.	Min.
				°	°	°	°
August 9	August 23	15	1	91	71	88	65
August 10	August 25 (died)	16	2	91	71	88	67
August 18	September 7	21	6	82	68	......	......
August 18	September 12	26	7	82	68	......	......
September 25	October 12 (two molts)	18	7	73	60	......	......

PUPA.

When pupated.	When issued.	Duration.	Rain, number of days.	Temperature.		Humidity.	
				Max.	Min.	Max.	Min.
				°	°	°	°
August 9	August 20	11	0	91	71	89	65
August 23	September 2	10	2	91	68	82	60
August 28	September 12	15	5	81	68	......	......
August 28	September 13	16	6	80	68	......	......
August 28	September 16	19	8	79	67	......	......
August 28	September 17	20	8	79	67	......	......
August 31	September 27	27	14	79	66	......	......
September 4	September 20	16	7	80	67	......	......
September 7	September 30	22	15	79	68	......	......

These data may be studied in the order given.

EGG.—For the first two lots the temperature is the same with only a slight difference in humidity, but during the period of the first lot rain fell for a part of the time on 3 successive days; during the second none fell at all. Under these conditions the duration of the first lot was 1½ days longer. The period covered by the next two lots of August 15 and August 16, furnish about the same conditions with the same results. The next three lots were deposited much later in the season, had lower temperature and excessive rains, 6.37 inches having fallen from September 22 to 25 inclusive. The duration of the egg state as a result was much prolonged. There is no check on this lot, however, since no eggs under direct observation were hatched during that season with the same low temperature but without the excessive rains. From general observations, however, there is no question but that low temperatures also prolong the duration of the egg state, the same as the rains seem to have done in each of the two first lots mentioned.

Larva.—The first two larvæ were reared under almost exactly similar conditions and, as will be seen, matured almost at the same time. As compared with those that follow the duration is of interest, as there was but little rain and a high temperature. The next two were worms hatched from the same lot of eggs, and, as is seen from the table, were reared under exactly similar conditions. Despite this, the difference in time of maturing is 5 days. This can only be accounted for by the peculiarities of the species, such as have been previously discussed. The difference, as compared with the two preceding, was principally due to the much lower temperature. If, with the abundant rain during that

period, the temperature had been maintained as high as in the first, the worms would have matured more rapidly. This is verified by noticing the retardation of growth of the last worm recorded in the table. This worm had only molted twice after 18 days. The temperature during this period was 18° lower than that of the first two and 9° lower than that of the second two. General observations established this fact concerning the feeding of the worms, viz: that a moderate amount of rain with high temperature was least suited to their most vigorous feeding and growth, and consequently their earliest maturity. The same amount of rain, however, with a much lower temperature, is as much a disadvantage, and increases the retarding effect, which the lower temperature itself would have had. But again, high, dry temperatures are avoided by the worms, which during that time feed less vigorously, and thereby prolong their larval existence some.

Light frosts began (both in Mississippi and Louisiana) as early as October 27, and were more or less continuous from that time on. At Holly Springs, Mississippi, a killing frost occurred October 31, which froze and entirely blackened the cotton plants. At Shreveport, Louisiana, however, the cotton was not entirely frozen and blackened until about December 4. As has been previously noted, worms of nearly all stages were found at both localities a short time previous to the killing frosts, by which latter the younger ones were quite certainly killed.

Pupa.—For the first of the pupæ recorded it is found that a moderate amount of rain with high temperature shortens the duration of the pupal state. From the remaining ones it is found that with but little variation in the low temperature, which alone would have prolonged the duration, the excessive rains greatly added to the delay.

In general, then, it may be stated that the duration of the various stages of Heliothis are shortest under high temperatures with moderate rainfall; longer, except in egg and pupa, when a high, dry temperature is maintained; longer still with much lower temperature; and yet again longer with lower temperature and excessive rains.

Some atmospheric conditions also noticeably influence the behavior of the moths. The hot weather, dry, or somewhat rainy, seems to have but little diverting effect on the habits of the moths. When the temperature is much lower, and is accompanied with much rain, the moth adapts itself to the condition of things. The excessive rains last season continued late in the evening and into the night. This of course covers the period of feeding and deposition. This seemed to have the effect of inducing the moths to fly and feed more freely during the middle of the afternoon, when it was clear and warmer. When the rainy spell began to be a protracted one, the females were frequently seen at 3 o'clock during the warm sunshiny afternoons busily engaged in depositing their eggs. The instances in which deposition was observed in daytime were confined mostly to this period, though some were observed under normal conditions. From this it follows that to a certain

extent, at least, the imagos adapt themselves to unfavorable conditions, and that their period of egg deposition, on the whole, is not much influenced by such conditions. Their progeny, however, as has already been noted, suffers materially.

As bearing on the abundance (or rather scarcity) of the Boll Worm the past year, I quote from the report of Professor Fulton for 1890 as follows: "The most important irregularities of the year were the unusually high temperature in January and February, with a marked deficiency of temperature in March." During the period of high temperature in January, and especially February, it may be that many of the moths issued. If so, the cold period in March quite likely killed many of those which had issued. In the Red River section of Louisiana the Red River overflowed badly in spring, and planting of both corn and cotton was delayed until late in May and some in June. This necessarily delayed finding suitable host plants for the moths which had issued during April and May to deposit on, and doubtless a large per cent of their progeny failed to survive. In some localities also corn and cotton had been planted and was large enough for the moths which had issued to deposit upon when the river overflowed. As a result the corn and cotton both were drowned, or at any rate stunted so that it was all plowed under and planted a second time. By this process doubtless many of the first brood of worms were destroyed. From these reasons the second brood and consequently all subsequent broods were in all probability greatly reduced.

From all the information gathered through observers of the U. S. Signal Service it is certain that the boll-worm depredations are much more extensive in the southern portion of the cotton belt. There is, therefore, no question but that the future work on the Boll Worm should be carried on principally in that region.

INSECT DISEASES.

The work upon insect diseases has formed an important part of the investigation. At the present time, however, it would be unwarranted and hazardous to enter largely into a report upon the work done and in contemplation, or to draw conclusions. I shall therefore give but little more than a synopsis of the present condition of the work, and will reserve acknowledgments to those who have contributed in any way for a more detailed report in the future.

The first thing to be done in preparing for such work was to equip and arrange for a bacteriological laboratory. Some time was spent at Shreveport, Louisiana, in coöperation with Dr. Booth (who assumed charge of the work for the season) towards accomplishing this end. Hot-air and steam sterilizers were designed and a good workman soon had them in condition for use. The other supplies immediately necessary were ordered. These have been added to as the progress of the

work demanded, until now quite a complete laboratory has been fitted up, sufficient to carry on to a finish all the work and experimentation which it will be possible to execute.

The diseased insects and worms from which the cultures on hand have been made were obtained from various sources from entomological workers throughout the country.

Extensive and conclusive experiments with the insect diseases on hand were not made for the same reasons stated by Professor McNeill. The status of this portion of the work is, therefore, much the same as the latter, viz, ready for extensive and thorough work during the approaching season. The few observations made are encouraging, but do not warrant any definite and positive statements at this time.

It seems highly probable that the Boll Worm is readily susceptible to the cabbage-worm disease. Dr. Booth in one instance fed Boll Worms upon diseased cabbage worms, which Boll Worms later died. Cultures were obtained from these dead Boll Worms. Mounts from the cultures were made later and studied with a microscope. Micrococci were present in great abundance. At Holly Springs, Mississippi, some Boll Worms were accidentally placed in a breeding cage in which dead cabbage worms had been temporarily placed. A number of these Boll Worms died at various intervals. The dead worms were sent to Dr. Booth, who made cultures from their dead and decaying bodies. Examination of mounts made from these cultures again showed micrococci in abundance. The above evidence is not direct and positive; is merely indicative, and at best unscientific. It consists simply of observations noted during the progress of the work, and simply indicates that scientific experiments may prove successful.

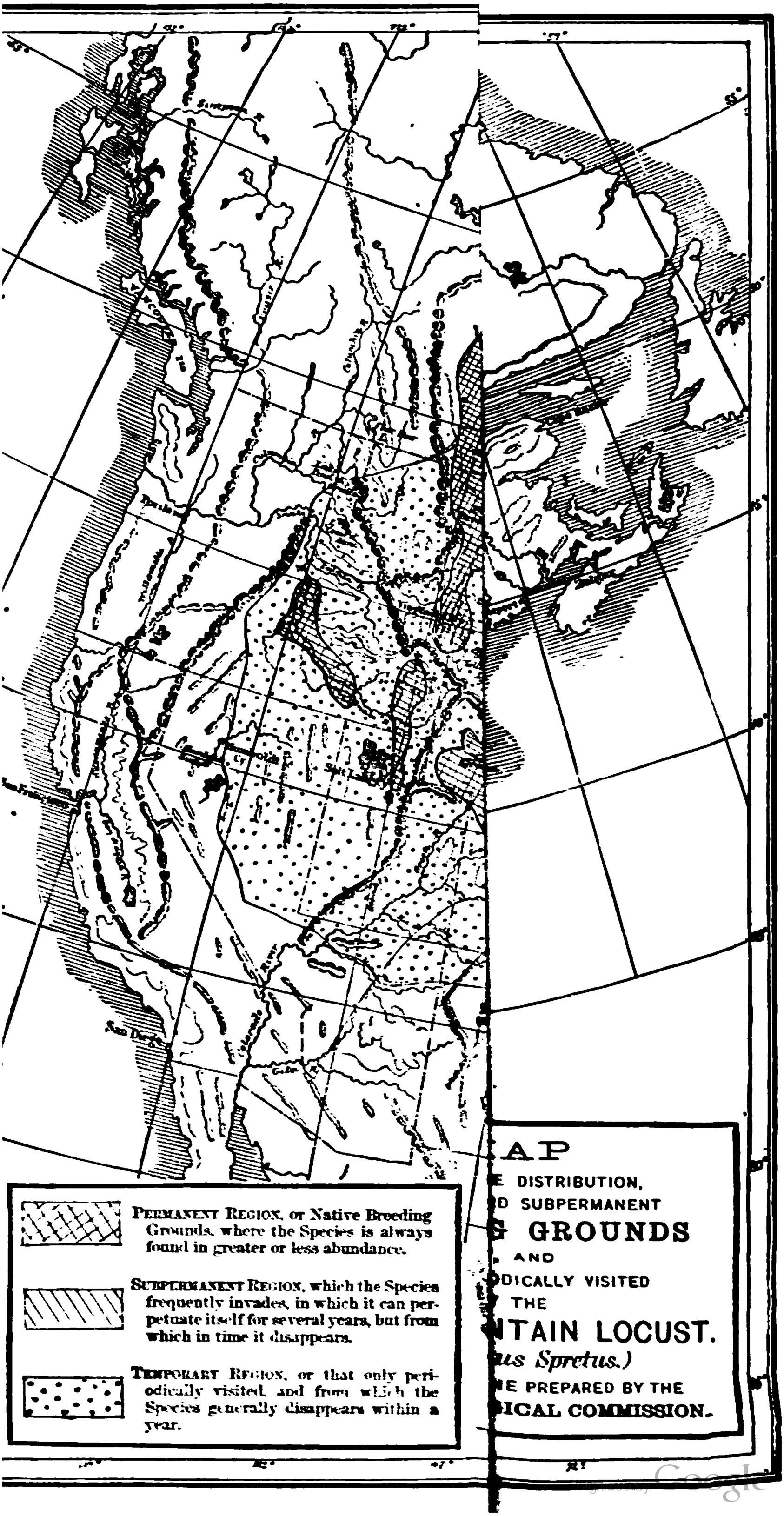
Though no experiments could be made upon the Boll Worms with *other* insect diseases, the interesting and important discovery was made at Holly Springs, Mississippi, that the Boll Worm itself is subject to a disease. The disease is not confined to the larval stage, but has been obtained from all the stages of the species. Two females issued on the night of September 14. On the second day, it was noticed that the moths were rather sluggish and that the abdomen was greatly distended. By the next day the females were absolutely helpless, and the abdomen so decomposed that it barely held together while pinning the moth. The last signs of life of the moth consist of peculiar alternate openings and closings, contracting and expanding of the anus and genital organs. At the time it did not occur to me that it was a disease of the species, and it was only the peculiar manner of the dying of the moth which had attracted my attention. Hence it was that the moths were simply pinned and placed in insect boxes. This was done September 17. November 28, the abdomen of the moth was accidentally broken off and the internal parts were found to be partially liquid. From this partially liquid portion tubes of beef broth were inoculated, as also from a whitish, waxy, gelatinous substance in the extreme poste-

rior end of the abdomen. A culture was obtained from the waxy portion, and the microbe is different from any of the others studied. It is possible that the cultures obtained from the moths after so long a time are non-pathogenic microbes, instead of the one which produced the disease of the imago. No positive statements will therefore be given until experiments have been made. Cultures from the egg, larvæ and pupæ are in stock, and, so far as examined, are all exactly alike. This disease can not have been mistaken for any other, since it was noted before any of the others were on hand. Thus, having probably found the Boll Worm subject to a disease perhaps peculiar to itself, it remains to be seen whether it is contagious and easily disseminated for infection.

In addition to this, a disease of each of the two larvæ whose ravages are easily mistaken for those of the Boll Worm was also discovered at Holly Springs, Mississippi. The two species are *Prodenia lineatella* and the undetermined Noctuid spoken of. In fact the disease of each was so prevalent, that but few of the worms were found, and of those found all but one, which had been placed in alcohol, died of the disease. No great apprehensions need therefore be had concerning these two species.

Diseases of *Agrotis messoria*, *Nephelodes minians*, as also of the large tomato worm, are at hand in the form of cultures.

Cultures from all these sources were begun in August, 1890. By the regular methods for such work pure cultures have now been obtained and are transferred from time to time to fresh media, in order to continue the healthy growing germs through the winter and in good condition for the approaching season's experimental work. In this way a vast number of cultures in fine condition are on hand, and it is to be hoped that abundant opportunity may be offered this season to execute extensive and thorough experiments.


PERMANENT REGION, or Native Breeding Grounds, where the Species is always found in greater or less abundance.
SUBPERMANENT REGION, which the Species frequently invades, in which it can perpetuate itself for several years, but from which in time it disappears.
TEMPORARY REGION, or that only periodically visited, and from which the Species generally disappears within a year.
AP
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ICAL COMMISSION.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 25.

DESTRUCTIVE LOCUSTS.

A POPULAR CONSIDERATION OF A FEW OF THE MORE INJURIOUS LOCUSTS (OR "GRASSHOPPERS") OF THE UNITED STATES, TOGETHER WITH THE BEST MEANS OF DESTROYING THEM.

BY

C. V. RILEY, M. A., Ph. D.,
ENTOMOLOGIST.

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CONTENTS.

LETTER OF SUBMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 28, 1891.

SIR: I have the honor to submit for publication Bulletin No. 25 of this Division, being a consideration of a few of the commoner and more destructive locusts of the United States, together with the best remedies to be used against them.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

DESTRUCTIVE LOCUSTS.

INTRODUCTION.

Since the great "grasshopper years" of 1873–'76 there have been frequent outbreaks of comparatively local species, as well as a few cases in which small swarms of the Rocky Mountain Locust have flown out into the subpermanent region and have occasioned some damage for a year or so. The most notable cases have been the outbreaks of the Lesser Migratory Locust in New Hampshire in 1883 and 1889, the extraordinary multiplication of the Devastating Locust in California in 1885, the increase of local species in Texas in 1887, the multiplication of a chance swarm of the Rocky Mountain species in a restricted locailty in Minnesota in 1888, and last year's damage in Idaho by several non-migratory species combined.

For a number of years the First and Second Reports of the United States Entomological Commission, which contained the results of the labors of the commission upon the Rocky Mountain Locust, have been out of print, and yet with every renewed alarm caused by locusts there has been a great demand upon this Division for information, which could only be supplied by correspondence or by publishing the information in local newspapers. For a time the demand was filled by supplying the Annual Report of this Department for 1877, which contained bodily the chapters upon remedies from the first commission report. The supply of this document was also soon exhausted.

The fact that Mr. Bruner in his last summer's trip to Idaho investigated the latest rumors and found that considerable damage was being done and that the farmers were not acquainted with even the most rudimentary measures for protection and remedy, shows the necessity of publishing a condensed and practical account of the species which become seriously injurious from time to time, and of republishing in as brief form as possible the matter on remedies and preventives from the reports mentioned. This bulletin is the result. It is, in fact, a reproduction of matter already published but now inaccessible for dissemination, and which, from its nature, has a permanent value, together with such additional facts as subsequent experience has revealed. It contains no technical matter whatsoever, and the farmer will be able to recognize the different species from the figures which accompany the

consideration of each. The portion which relates to remedies, while drawn up for use against the Rocky Mountain Locust, will apply in large part to other migratory locusts, as well as to the non-migratory species. Long, detailed descriptions of the various machines which were given in the original reports are, for the most part, omitted, in the belief that the figures themselves will be sufficiently suggestive for the present purpose. In point of fact, many of these machines, especially the more complicated, while serviceable, cannot be recommended to the average farmer dealing with the locust plague, and experience has shown that those simple forms providing for the use of coal oil and coal tar are, on the whole, the most efficacious against the unfledged insects. It is, therefore, to this portion of the bulletin that I would particularly call the attention of those needing the information contained in it. But little experience of practical value has been had since the last great invasion; hence little has been added to this section of the bulletin beyond a brief description of the trapping system used in Cyprus against the migratory locusts of the Old World, and an account of the bran-arsenic mash remedy used in California in 1885 against the Devastating Locust.

C. V. R.

THE ROCKY MOUNTAIN LOCUST.

(*Caloptenus spretus* Thomas.)

Range of Species.—In the first report of the U. S. Entomological Commission this species has been fully treated, and the region over which it is found divided into the *Permanent*, *Subpermanent*, and *Temporary*

Fig. 1.—*Caloptenus spretus*: Process of acquiring wings: *a*, pupa with skin just split on the back; *b*, the imago extending; *c*, the imago nearly out; *d*, the imago with wings expanded; *e*, the imago with all parts perfect, natural size (after Riley).

regions. These may be briefly explained as follows: *Permanent*, that in which the locust breeds each year and is always to be found in greater or less numbers; *Subpermanent*, that in which it is liable to breed for some years, when it multiplies in excessive numbers in its truly permanent breeding grounds, but from which it in time disappears; *Temporary*, that over which the locusts migrate in years of excessive abundance, but in which they seldom breed and generally disappear within a year. The *Permanent* region embraces the greater part of Montana, a narrow strip of western Dakota, all but the northwestern quarter of Wyoming, the central and northwestern portion of Colorado, a small tract in north central Utah and southeastern Idaho, another similar tract in eastern Oregon and southern Idaho, and a very large area in the British possessions north of Montana which equals more than one-third of the whole region. The *Subpermanent* region lies immediately east of this, taking in a part of Manitoba, nearly all of Dakota, the western half of Nebraska, and the northeastern quarter of Colorado. The *Temporary* region extends to within from 250 to 300 miles of the Pacific coast, then taking in northern Arizona and New

Mexico, all of Texas, Indian Territory, Kansas, Nebraska, western Missouri, the greater half of Iowa, nearly all of Minnesota, besides an additional strip in the British possessions which includes Manitoba and the country north to Lake Winnipeg.

DESTRUCTIVE APPEARANCES.—In Chapter II of the first report of the Entomological Commission the chronological history of this locust is treated at length. We introduce here a short resumé of these appearances:

1818 and 1819. Minnesota and Red River region in Manitoba.
1820. Western Missouri, probably also Kansas and country to north.
1842. Minnesota and Wyoming.
1845. Texas.
1846 and 1847. Wyoming.
1849. Texas and possibly Minnesota.
1851–1872 and 1875–1877. Every one of these years in Utah.
1852. Idaho.
1853. Dakota.
1854. Texas, Kansas.
1855. Texas.
1856. Texas, Kansas, Iowa, Minnesota, possibly Wyoming.
1857. Texas, Kansas, Nebraska, Iowa, Minnesota, Wyoming, Manitoba.
1860. Topeka, Kansas.
1861. Nebraska, Montana.
1862. Montana.
1863. Montana, Dakota, Minnesota.
1864. Montana, Dakota, Colorado, parts of New Mexico, Nebraska, Iowa, Minnesota, Manitoba.
1866. Kansas, Nebraska, northeastern Texas, western Missouri, Iowa, Minnesota, Colorado.
1868–1869. Montana, Idaho, Dakota, Colorado.
1870. Iowa, Minnesota, and slight in Dakota, Idaho, Wyoming.
1872. Slight in Minnesota, Dakota, Montana, Colorado.
1873. Northern Colorado, southern Wyoming, Nebraska, Dakota, southwest Minnesota, northwest Iowa.
1874. Colorado, Nebraska, and Kansas overrun, while parts of Wyoming, Dakota, Minnesota, Iowa, Missouri, New Mexico, Indian Territory, and Texas were ravaged by swarms from Montana and British America where they were abundant. This was the year of the most disastrous invasions.
1875. Portions of Kansas, Nebraska, Missouri; also more or less abundant and destructive from Manitoba to Texas.
1876. Montana, British America, Wyoming, Dakota, Minnesota, Colorado, Kansas, Nebraska, west half of Iowa, west strip of Missouri, Indian Territory, Texas.
1877. Minnesota, Iowa, Dakota, Montana.
1885. Eastern Montana, northwest Dakota.
1888. Minnesota, principally Otter Tail County.

LIFE-HISTORY AND HABITS—*Where the Eggs are laid.*—The eggs may be laid in almost any kind of soil, but by preference they are laid in bare, sandy places, especially on high, dry ground, which is tolerably compact and not loose. It is often stated that they are not laid in meadows and pastures, and that hard road-tracks are preferred; in truth, however, meadows and pastures, where the grass is closely grazed, are much

used for ovipositing by the female, while on well-traveled roads she seldom gets time to fulfill the act without being disturbed. Thus a well-traveled road may present the appearance of being perfectly honey-combed with holes, when an examination will show that most of them are unfinished and contain no eggs; whereas a field covered with grass stubble may show no signs of such holes and yet abound with eggs. In fact, wherever holes are noticed, it may generally be taken for granted that they contain no eggs, for the mother covers well the hole when she has time to properly complete her task.

Furthermore, the insects are more readily noticed at their work along roads and roadsides than in fields; a fact which has also had something to do in forming the popular impression. Newly plowed land is not liked; it presents too loose a surface; but newly broken sward is often filled with eggs. Moist or wet ground is generally avoided for the purpose under consideration.

We have noticed that in the permanent breeding region, wherever the vegetation is scant, the females show a decided preference for the shaded base of shrubby plants, among the roots of which they like to place their eggs; whereas in the temporary region, where the vegetation is generally so much ranker, exposed situations, or those comparatively bare of vegetation, are preferred. The experience of 1876 proved very conclusively, also, that they are instinctively guided toward cultivated fields, where the young will find good pasturage; for the eggs were noticeably thickest and hatched most numerously in 1877 in cultivated areas. In the Cypress Hills region of British America, as Mr. J. G. Kittson informs us, the high lands and protected slopes of the hills are preferred. The soil of the mountain region, where the insects permanently breed, is mostly of a compact, scantily covered, gravelly nature, and the notion that they lay most in pure sand is an erroneous one.

Sandy soil that is compact, especially when having a south or east exposure, is much chosen, but in loose and shifting sand the eggs would perish. In 1876, it was generally remarked that the insects were more indifferent than usual in ovipositing, and that eggs were much more frequently laid in low, and even wet, land than in former years.

The mass seldom reaches more than an inch below the surface, except where some vegetable root has been followed down and devoured, and the insect leaves her eggs before emerging; in this way the mass is sometimes placed a foot below the surface. In abnormal or unhealthy conditions, the eggs may be laid in exposed places without any hole, in which case they doubtless never give birth to young. In other cases, the female will fill her hole almost entirely with the sebific matter. Nor are the eggs invariably laid in the ground, for while we know of no exceptions to this normal position in *spretus*, yet Mr. Boll informs us that around Dallas, Tex., in 1876, the eggs of *differentialis* were very numerously placed under the bark of elm and hackberry logs that had been

felled on low land. We have also received from Mr. A. W. Hoffmeister, of Fort Madison, Iowa, the eggs of a species of *Stenobothrus*, and the young that hatched from them, the eggs having been thrust into holes made by some carpenter-bee in a fence-post; while *Chlöealtis conspersa* habitually bores in dead wood.

Manner in which the Eggs are laid.—The female, when about to lay her eggs, forces a hole in the ground by means of the two pairs of horny valves which open and shut at the tip of her abdomen, and which, from their peculiar structure, are admirably fitted for the purpose. (See Pl. I, Fig. 2, where *b*, *c*, show the structure of one of each of the upper and lower valves.) With the valves closed she pushes the tips into the ground, and by a series of muscular efforts and the continued opening and shutting of the valves she drills a hole, until in a few minutes (the time varying with the nature of the soil) nearly the whole abdomen is buried. The abdomen stretches to its utmost for this purpose, especially at the middle, and the hole is generally a little curved, and always more or less oblique (Pl. I, Fig. 1, *d*). Now, with hind legs hoisted straight above the back, and the shanks hugging more or less closely the thighs, she commences ovipositing.

When the hole is once drilled there exudes from the tip of the body a frothy, mucous matter, which fills up the bottom of the hole and bathes the horny valves. This is the sebific fluid which is secreted by the sebific or cement gland. By repeatedly extricating and studying specimens in every possible stage of oviposition we have been able to ascertain the exact method by which the egg-mass is formed. The process has never been accurately described by other writers, and the general impression—upon which figures like those of Gerstäcker's * are founded—is that the eggs are extruded from between the distended hooks or valves. If we could manage to watch a female from the time the bottom of her hole is moistened by the sebific fluid, we should see the valves all brought together, when an egg would pass down the oviduct (Pl. I, Fig. 3, *j*) along the ventral side, and, guided by a little finger-like style (the *gubernaculum ovi*, *g*), "pass in between the horny valves (which are admirably constructed, not only for drilling but for holding and conducting the egg to its appropriate place), and issue at their tips amid the mucous fluid already spoken of. Then follows a period of convulsions, during which more mucous material is elaborated, until the whole end of the body is bathed in it, when another egg passes down and is placed in position. These alternate processes continue until the full complement of eggs are in place, the number ranging from 20 to 35, but averaging about 28. The mucous matter binds all the eggs in a mass, and when the last is laid the mother devotes some time to filling up the somewhat narrower neck of the burrow with a compact and cellulose mass of the same material, which, though light and easily penetrated, is more or less impervious to water,

* Die Wanderheuschrecke, Berlin, 1876, Taf. II, Fig. 4.

and forms a very excellent protection (Pl. I, Fig. 5, *d*)." When fresh the mass is soft and moist, but it soon acquires a firm consistency.

During the operation the female is very intent on her work, and may be gently approached without becoming alarmed, though when suddenly disturbed she makes great efforts to get away, and extricates her abdomen in the course of a few seconds, the time depending on the depth reached.

The legs are almost always hoisted straight above the back during the process, as shown in the figure (Fig. 1), with the shanks hugging more or less closely the thighs. Sometimes, however, especially when the abdomen is fully buried, the ends of the hind feet may rest firmly on the ground, as has been observed by Dr. Packard in the case of *femur-rubrum*.

The time required for drilling the hole and completing the pod will vary according to the season and the temperature. During the latter part of October or early in November, 1876, when there was frost at night and the insects did not rouse from their chilled inactivity until 9 o'clock a. m., the females scarce had time to complete the process during the 4 or 5 warmer hours of the day; but with higher temperature not more than from 2 to 3 hours would be required.

We have been for weeks with the insects where they were so thickly ovipositing that the light, clay-yellow ground would be darkened by them, and have laid on a closely-grazed sward for hours with specimens in the act all around, and have repeatedly verified all that we have here described.

Philosophy of the Egg-mass.—To the casual observer the eggs of this locust appear to be thrust indiscriminately into the hole made for their reception. A more careful study of the egg-mass, or egg-pod, will show, however, that the female took great pains to arrange them, not only so as to economize as much space as possible, consistent with the form of each egg, but so as to best facilitate the escape of the young locust; for if, from whatever cause, the upper eggs should fail to hatch, or should hatch later than the lower ones, the former would offer an impediment to the exit of the young in their endeavors to escape from these last, were there no provision against such a possibility. The eggs are, indeed, most carefully placed side by side in four rows, each row generally containing seven. They oblique a little crosswise of the cylinder (Pl. I, Fig 4, *a*). The posterior or narrow end, which issues first from the oviduct, is thickened, and generally shows two pale rings around the darker tip (Pl. I, Fig 5, *b*). This is pushed close against the bottom of the burrow, which, being cylindrical, does not permit the outer or two side rows to be pushed quite so far down as the two inner rows, and for the very same reason the upper or head ends of the outer rows are necessarily bent to the same extent over the inner rows, the eggs when laid being somewhat soft and plastic. There is, consequently, an irregular channel along the top of the mass (Pl. I, Fig. 5, *c*), which is

filled only with the same frothy matter that surrounds each egg, which matter occupies all the other space in the burrow not occupied by the eggs. The whole plan is seen at once by a reference to the figure referred to, which represents, enlarged, a side view of the mass within the burrow (*a*), and a bottom (*b*) and top (*c*) view of the same, with the earth which adheres to it removed.

Number of Egg-masses laid by a single Female.—Yersin concludes, referring to the European *migratoria*, that eggs are laid thrice, at intervals of about a month, while Krünitz, Keferstein, and Stoikowitsch † also declare that they are laid in three different masses. Professor Whitman, in his 1876 experiments, had a female which laid about the middle of July, and died September 9, without laying again, though eggs were found in the ovaries at death. The time between the first and second laying, observed by Körte, was 6 days. Mr. Aughey, from experiments made in 1876, found the interval still shorter, ranging from 2 to 3 days; but he requests us to add that other experiments, not recorded, showed a much longer interval between the periods, extending in some cases to 20 days. It would thus appear that there is the greatest diversity in the time intervening between the periods of egg-laying and that the number of egg-masses formed by one individual is by no means constant. It is natural to suppose that there will be great difference in individual prolificacy, and we are also of the opinion that there is great difference in this respect in different generations—those that hatch in the permanent region being more prolific than those which hatch in the temporary region. This opinion is not only warranted by the general experience of farmers, but also by experiment. As compared with those of 1876, the autumn flights of 1877 were for the most part intestate, and it was very generally noticed that they laid no eggs. There is, as we have seen in the preceding chapter, the best of reasons for believing that these flights were not from the permanent region, but consisted mainly of insects that had bred in the temporary region.

It is well known that the reproductive organs are easily affected by any sudden change of climatic conditions which animals may be subjected to, and that sterility is one of the most frequent consequences of such change. It was upon this general rule that the late B. D. Walsh, knowing nothing of the return migration, based the theory that the Rocky Mountain locust could never thrive in the temporary region, but would become intestate and perish there. In 1876 we had measurable success in getting *spretus* to lay eggs in confinement. In 1877, though we made far more strenuous efforts with the insects that hatched in Texas and Kansas, yet we signally failed. Of many thousands which we hatched in St. Louis and endeavored to rear under the most favorable circumstances in vivaria containing growing grain, most of them died in from 3 to 8 days from hatching. We succeeded in bringing a few through the third and two through the fourth molt. At Carbondale, Ill., from

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† See Koppen, p. 36.

Minnesota eggs, Mr. Thomas had better luck, and reared several to the winged condition. We repeatedly dispatched living specimens both of the pupæ and the mature insects from Texas, Kansas, and Iowa to our office clerk, Mr. Th. Pergande, St. Louis, but with no more favorable results, as he entirely failed to obtain eggs, and the females, when dead, were found, upon examination, to contain none. This want of fecundity, though not universal, was quite general with the insects of 1877, and is in keeping with the general experience as to the sickly and degenerate nature of the brood.

It is quite manifest, therefore, that in answering the question we have just asked we can do so only in a general and qualified manner. The number of eggs produced by a well-developed locust will range from 100 to 150, if we consider species generally. We have counted 171 in one mass of *Caloptenus differentialis;* from 120 to 130 in those of *Œdipoda phanæoptera*, and about 120 in that of *Acridium americanum.* The great probability is that the eggs of such species are all laid at once. In species like *spretus*, which rarely lay more than 30 eggs in one mass, it were natural to infer that different layings take place, even did the facts at hand not prove such to be the case. In 1876 the insects were pushing continuously southward from the middle of August till the end of October, and during most of this time they were laying eggs. In fact, throughout the country invaded, from Minnesota to south Texas, they continued laying till frost, and we know from examinations that many of them perished before all the ova had been disposed of. Stragglers were even noticed in Texas as late as December.

To sum up the inquiry, we would give it as our belief that the laying season normally extends from 6 to 8 weeks; that it may be shortened or lengthened by conditions of weather and climate; that fecundity is materially affected by the same conditions; that the average number of egg masses formed is three; and that the average interval between the periods of laying by the same female is 2 weeks.

The Hatching Process.—Carefully examined, the eggshell is found to consist of two layers. The outer layer, which is thin, semiopaque, and gives the pale, cream-yellow color, is seen by aid of a high magnifying power to be densely, minutely, and shallowly pitted; or, to use still more exact language, the whole surface is netted with minute and more or less irregular, hexagonal ridges (Pl. I, Fig. 4, *a*, *b*). It is a mere covering of excreted matter, similar in nature to the mucous or sebific fluid already described, which binds the eggs together. The inner layer (or *chorion*) is thicker, of a deeper yellow, and perfectly smooth. It is also translucent, so that, as the hatching period approaches, the form and members of the embryon may be distinctly discerned through it. The outer covering is easily ruptured, and is rendered all the more fragile by freezing; but the inner covering is so tough that a very strong pressure between one's thumb and finger is required to burst it. How, then, will the embryon, which fills it so compactly that there is scarcely

room for motion, succeed in escaping from such a prison? The rigid shell of the bird's egg is easily cracked by the beak of its tenant; the hatching caterpillar, curled within its eggshell, has room enough to move its jaws and eat its way out; the egg-coverings of many insects are so delicate and frail that the mere swelling of the embryon affords means of escape; those of others are so constructed that a door flies open, or a lid lifts by a spring, whenever pressure is brought to bear; in some, two halves open, as in the shell of a mussel; whilst in a host of others the embryon is furnished with a special structure called the egg-burster, the office of which is to cut or rupture the shell, and thus afford means of escape. But our young locust is deprived of all such contrivances, and must have another mode of exit from its tough and sub elastic prison. Nature accomplishes the same end in many different ways. She is rich in contrivances. The same warmth and moisture which promote the development of the living embryon also weaken the inanimate shell, by a process analogous to decomposition, and by a general expansion consequent upon the swelling of the embryon within. Thus, the eggs when about to hatch are much more plump and somewhat larger and more transparent than they were when laid. At last, by the muscular efforts of the nascent locust, and the swelling of its several parts, especially about the head and mouth, the shell gives way, generally splitting along the anterior ventral part. The whole process may, in fact, be likened to the germination of a hard-covered seed, when planted in moist ground, and, precisely as in this latter case, there is in some loose soils a certain heaving of the ground from the united swelling of the locust eggs. All the eggs in a given mass burst very nearly at one and the same time, and in that event the lowermost individuals await the escape of those in front of them, which first push their way out through the neck of the burrow (Pl. I, Fig. 4, *d*) provided by the parent.

They all escape, one after the other, through one small hole, which in the field is scarcely noticeable. Such is the usual mode of hatching; but when the young from the lower eggs hatch first, or when the upper eggs perish and leave the lower ones sound—as is not unfrequently the case—the exit is nevertheless easily made along the channel already described (Pl. I, Fig. 5, *c*).

When once the shell is ruptured the nascent larva soon succeeds, by a series of undulating movements, in working free therefrom and making its way to the light in the manner just described. Once on the surface of the ground it rests for a few minutes, generally lying on the side. Its members are still limp and directed backward, and it is yet enveloped in a very delicate film or pellicle, which must be cast off before the little creature can move with alacrity.

By continuance of similar contracting and expanding movements which freed the animal from the earth, this film in a very short time splits along the middle of the back near the head (strictly the protho-

rax,) and is then worked off behind, and finally kicked from the hind feet in a little white crumpled pellet, that has justly been likened by some of our correspondents to a diminutive mushroom. These little pellets invariably lie close around the hole in the ground from which the young locusts issued. The pellicle begins to split, under ordinary conditions of warmth, within a minute from the time the locust is fairly out of the ground, and is shed in from one to five minutes, according to circumstances. Pale and colorless when first freed from this pellicle, the full-born locust is nevertheless at once capable of considerable activity, and in the course of an hour assumes its natural dark gray coloring. Dr. Packard observed (Report to Dr. Hayden, 1877, p. 634) that specimens which hatched at 11 a. m. began to turn dark at 3 p. m., thus showing that the time may vary; but numerous close observations which we have made on single individuals show that an hour seldom passes after the amnion is thrown off before the gray color is acquired.

From this account of the hatching process, we can readily understand why the female in ovipositing prefers compact or hard soil to that which is loose. The harder and less yielding the walls of the burrow, the easier will the young locust crowd its way out.

Though the covering which envelops the little animal when first it issues from the egg is quite delicate, it nevertheless, in the struggles of birth, undoubtedly affords much protection, and it is an interesting fact that while, as we have just seen, it is shed within a few minutes of the time when the animal reaches the free air, it is seldom shed if, from one cause or other, there is failure to escape from the soil, even though the young locust may be struggling for days to effect an escape.

While yet enveloped in this pellicle, the animal possesses great forcing and pushing power, and, if the soil be not too compact, will frequently force a direct passage through the same to the surface, as indicated at the dotted lines (Pl. I, Fig. 5, *e*). But if the soil is at all compressed it can make little or no headway, except through the appropriate channel (*d*). While crowding its way out the antennæ and four front legs are held in much the same position as within the egg, the hind legs being generally stretched. But the members bend in every conceivable way, and where several are endeavoring to work through any particular passage, the amount of squeezing and crowding they will endure is something remarkable. Yet if by chance the protecting pellicle is worked off before issuing from the ground, the animal loses all power of further forcing its way out. The instinctive tendency to push upward is also remarkable. In glass tubes, in which I have had the eggs hatching in order to watch the young, these last would always turn their heads and push toward the bottom whenever the tubes were turned mouth downward; while in tin boxes, where the eggs were placed at different depths in the ground, the young never descended, even when they were unable to ascend on account of the compactness of the soil above.

Where and under what Conditions of Soil the Young hatch most freely.—The eggs will hatch under the most varied conditions. As a rule, the soils and locations preferred by the female in ovipositing will be those in which the young will most freely hatch, viz, compact and sandy or gravelly knolls and hillsides with a south or southeast exposure.

The experience of 1877 shows also that hatching takes place very freely in late-mown meadows or prairies or grazed pastures, where the exposure of the ground admits of ready oviposition and the warmth of the sun. In dry, well-drained, and compact soils of a light nature the eggs are much better preserved than in heavy clays and loams, where they are more subject to mold and rot. The experience of 1877 is rather misleading on this point, and indicates the necessity of generalizing, not from the experience of one, but of many years. The insects were most numerous, and seemed to hatch most numerously in the lowlands and in sheltered situations along river courses. The facts are, that in such situations those which did hatch survived in larger proportions than did those which hatched in more exposed places, because the former were better protected from the cold rains and storms of spring.

Time of Hatching.—Here, again, we can not take the experience of any one year as a guide, but find the necessity of generalizing from all past experience. In much of the locust area there prevailed such late warm weather in the autumn of 1876 that considerable numbers of the young hatched prematurely; and such is very generally the case. We had also some unseasonably warm weather in January and February, 1877, during which large numbers hatched. These all subsequently perished. During the latter part of March and early in April the hatching was general, but there followed a period of cold, rainy weather, which checked the hatching and destroyed a large number of the insects that had hatched. May and June were characterized by abundant rains and storms, alternating with warm, sunny weather, causing the hatching to be irregular and in some cases quite retarded. It would not be incorrect, therefore, to say that in one and the same neighborhood the hatching commenced on the 1st of February, and did not cease till the end of June, thus covering a period of 5 months. Yet this is exceptional, and it has been much more regular and the period more restricted in previous years.

Those eggs which are laid earliest the previous year will also hatch earliest; and since the egg-laying covers an average period of 6 or 8 weeks in the same locality and lasts generally till frost, it follows that the eggs pass the winter in every stage of development—some with the fluids clear and limpid, others with the embryo fully formed and ready at the first approach of spring to hatch. This we found also to be actually the case, for many hundreds of egg-masses examined during the winter of 1876–'77, from divers parts of the infested region, showed every state of development.

In the same locality hatching will take place—*cæteris paribus*—first

on light dry soils and on south and southeast exposures; latest on low, moist, and shaded or tenacious ground.

We see, therefore, that the hatching will not alone vary according to temperature and the earliness or lateness of the spring, but that it is quite variable under the same conditions. In every instance there will be a few hatching when the first hatched in the same locality are getting wings; and we give it as a general rule that the bulk of the eggs hatch out in the different latitudes about as follows:

In Texas, from the middle to the last of March.

In the southern portions of Missouri and Kansas, about the second week in April.

In the northern parts of Missouri and Kansas and the southern sections of Iowa and Nebraska, the latter part of April and first of May.

In Minnesota and Dakota the usual time for hatching ranges from early in May in the southern portions to the third week in the northern extremity.

In Montana and Manitoba, from the middle of May to the first of June.

In short, the bulk of the insects hatch in ordinary seasons about the middle of March in latitude 35°, and continue to hatch most numerously about four days later with each degree of latitude north, until along the forty-ninth parallel the same scenes are repeated that occurred in southern Texas seven or eight weeks before.

From a number of experiments which we have made on the eggs, we conclude that, with a constant temperature of 85° F., with favorable conditions of soil, the eggs will hatch in from four to five weeks after they are laid, and in a temperature of 75° F. in about six weeks. Dr. Riley has had the eggs of *Caloptenus atlanis* (laid in July) hatched in from three to four weeks; those of *Tragocephala viridifasciata* (laid in June) in three weeks; and those of *Acridium americanum* (laid in July) in rather more than a month.

Habits of the young or unfledged Locusts in the temporary Region.—The habits of the young insects as they occur in the temporary region, and particularly in the country south of the forty-fourth parallel and east of the one hundredth meridian, are as follows: Although possessed of remarkably active powers from the moment they leave the egg, yet so long as provision suffices for them on their hatching-grounds the young remain almost stationary and create but little apprehension. As soon, however, as the supply of food in these situations is exhausted, they commence to migrate, frequently in a body a mile wide, devouring, as they advance, all the grass, grain, and garden-truck in their path. The migrating propensity is not developed until after the first molt, and often not till after the second or third. Up to that time they are content to huddle in warm places, and live for the most part on weeds, and especially on the common Dog-fennel or May-weed (*Maruta*), where it is present.

The young locusts display gregarious instincts from the start, and congregate in immense numbers in warm and sunny places. They thus often blacken the sides of houses or the sides of hills. They remain thus huddled together during cold, damp weather. When not traveling, and when food is abundant, or during bad, rainy weather, they are fond of congregating on fences, buildings, trees, or anything removed from the moist ground. They also prefer to get into such positions to undergo their different molts. In fields they collect at night or during cold, damp weather, under any rubbish that may be at hand, and may be enticed under straw, hay, etc., scattered on the ground. Old prairie-grass affords good shelter, and where a wheat field is surrounded with unburned prairie they will gather for shelter along the borders of this last.

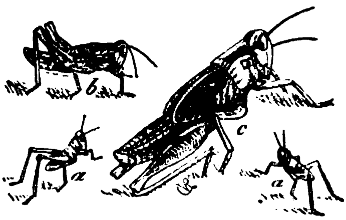

FIG. 2.—*Caloptenus spretus*: *a a*, newly hatched larvæ; *b*, full-grown larva; *c*, pupa, natural size (after Riley).

It is more particularly while they are yet small, or in the first, second, and third stages, that the young locusts hide at night, and, during unfavorable weather, at day also. In windy weather they are fond of gathering and secreting under any shelter, or in crevices and inequalities of the soil. At such times farmers too often conclude that the pests have perished and vanished; but a few hours of pleasant, sunny weather will bring the insects to sight again and dispel the delusion. When very vigorous and numerous they gradually move across a field of small grain and cut it off clean to the ground as they go, appearing to constantly feed. But when diseased or sickly, as in 1877, they gather in bare and sunny spots and huddle and bask without feeding. The very cold, wet weather that is prejudicial to them is beneficial to the grain, and under such circumstances it generally grows so rank and rapidly that they make little impression upon it.

It is when they are abundant and vigorous enough to bare the ground of vegetation, and this principally after they are half-grown, that the habit of migrating in large bodies is developed. In 1877 scarcely any disposition to migrate was shown, and this was in strong contrast with what occurred in 1875. In a year like this last, when they are vigorous and abundant, their power for injury increases with their growth.

At first devouring the vegetation in particular fields and patches in the vicinity of their birthplaces, they gradually widen the area of their devastation, until at last, if very numerous, they devour every green thing over extensive districts. Whenever they have thus devastated a country they are forced to feed upon one another, and perish in immense numbers from debility and starvation. Whenever timber is accessible they collect in it, and after cleaning out the underbrush, feed upon the dead leaves and bark. A few succeed in climbing up into the

rougher barked trees, where they feed upon the foliage, and it is amusing to see with what avidity the famished individuals below scramble for any fallen leaf that the more fortunate mounted ones may chance to sever. This increase in destructiveness continues until the bulk of the locusts have undergone their larval molts and attained the pupa state. The pupa, being brighter colored, with more orange than the larva, the insects now look, as they congregate, like swarms of bees. From this time on they begin to decrease in numbers, though retaining their ravenous propensities. They die rapidly from disease and from the attacks of natural enemies, while a large number fall a prey, while in the helpless condition of molting, to the cannibalistic proclivities of their own kind. Those that acquire wings rise in the air during the warmer parts of the day and wend their way as far as the wind will permit toward their native home in the Northwest. They mostly carry with them the germs of disease or are parasitized, and wherever they settle do comparatively little damage.

Directions in which the young Locusts travel.—The young insects when migrating move, as a rule, during the warmer hours of the day only, feeding, if hungry, by the way, but generally marching in a given direction until toward evening. They travel in schools or armies, to no particular or constant point of the compass, but purely in search of food—the same school one day often pursuing a different course from that pursued the day previous. On this point the experience of 1875 as well as of 1877 is conclusive, though the bulk of the testimony as to their actions, when hatching out in the more northern States, is to the effect that the prevailing direction taken is south or southeast, while in Southern Texas it is just opposite, or north. A person traveling along a road may often see one army marching in one direction to the left and another in the opposite direction to the right, and we have repeatedly had such an experience.

If, from any reason whatsoever, the vanguard of a column changes its course, the changed direction is in some way communicated in wave-like form to those in the rear. Usually, the front of a column is not easily diverted, however, but will pass through such obstacles as open fences rather than change course. Sometimes two schools going in different directions will cross each other, the individuals of either keeping to their particular course and presenting a singular spectacle as they hop past one another.

It is recorded in Europe that few things, not even water, stop the armies of the young locusts when on the march, and Döngingk relates having seen them swim over the Dniester for a stretch of 1¼ German miles, and in layers 7 or 8 inches thick.* We have had similar experience with our own species. In 1875, near Lane, Kans., they crossed the Pottawatomie Creek, which is about 4 rods wide, by millions; while

* Köppen, *loc. cit.*, p. 43.

the Big and Little Blues, tributaries of the Missouri, near Independence, the one about 100 feet wide at its mouth and the other not so wide, were crossed at numerous places by the moving armies, which would march down to the water's edge and commence jumping in, one upon another, till they would pontoon the stream, so as to effect a crossing. Two of these mighty armies also met, one moving east and the other west, on the river bluff, in the same locality, and each turning their course north and down the bluff, and coming to a perpendicular ledge of rock 25 or 30 feet high, passed over in a sheet apparently 6 or 7 inches thick, and causing a roaring noise similar to a cataract of water. (Riley's Eighth Report, p. 118.)

The experience of correspondents as to the movements of the young is very conflicting, as it naturally would be from what we have already said. One man will notice the insects moving with the wind, and conclude that it is the rule for them to do so; another, against the wind, and draw an opposite conclusion.

Rate at which the Young travel.—When about half-grown they seldom move at a greater rate than three yards a minute, even when at their greatest speed over a tolerably smooth and level road, and not halting to feed. They walk three-fourths this distance and hop the rest. Two consecutive hops are seldom taken, and any individual one may be run down and fatigued by obliging it to hop ten or twelve times without a rest.

According to Sydow, the young of the European *P. migratorius* travel, when at their most rapid gait, a German mile in four hours. Even taking the shortest German mile, or nearly four English miles, we very much doubt the accuracy of this statement, for though the *migratoria* is a larger species than *spretus*, we can not believe that it travels nearly ten times as fast, and we have again and again timed our own species.

They reach, in the temporary Region, but a few Miles east of where they hatch.—At the rate at which they travel, as just described, they could not extend many miles, even if they continued to travel in one direction from the time of hatching until maturity. They travel, on an average, not more than 6 hours per day; and their unfledged existence terminates in from 6 to 8, say 7, weeks. It is very easy to calculate from these facts that if they continued in one direction from the time they hatch until they acquire wings, they could not extend 30 miles. In reality, however, they do not travel every day; and where food is abundant they scarcely travel at all.

Moreover, as we have just shown, the migratory propensity is seldom manifested during the first or second larval stages, and it is, in fact, largely dependent on conditions of health and vigor of the insects and on the amount of food supply. We have learned of no cases where the young have extended, during growth, 10 miles east of the hatching limit.

As experience abundantly proves, the insects, when they get wings

in the temporary region, especially in early summer, instinctively fly to the north or northwest, and do not extend to do damage farther east. Those, also, which acquire wings later in the summer in more northerly regions, and which fly more to the south, never extend any great distance east of where they hatch; those developing on the eastern confines of the species' range (see map) passing southwestwardly, and those

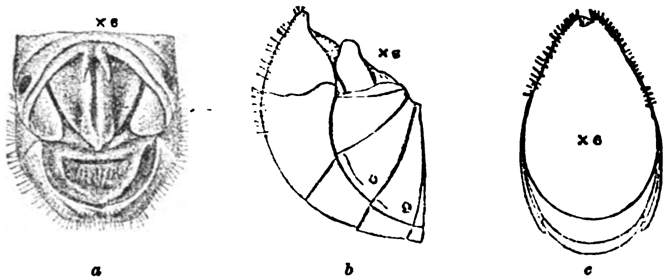

FIG. 3.—*Caloptenus spretus*, anal characters of male; *a*, from above: *b*, from the side: *c*, from below; enlarged six times (Emerton *del*).

born toward the mountains southeastwardly. In 1875, a few stragglers were carried as far as the center of Missouri, by being swept into the Missouri River, and drifting on logs and chips during the annual rise in July. But whenever scattering individuals are carried in this or any other way beyond the eastern limits we have laid down, they soon perish. Most of them are diseased or disabled, and if they lay eggs, these hatch in the autumn and perish at the approach of winter.

Rate at which Locust Swarms move.—The rate of migration of the winged insects will depend entirely on circumstances. The history of the past years of invasion shows conclusively that the rate of progress of invading swarms from the permanent breeding-places will average about 20 miles a day. It is, however, exceedingly irregular and greatly dependent on the velocity of the wind. Bad weather may impede or adverse winds divert flight.

One noticeable feature of the invasions is the greater rapidity with which the insects spread in the earlier part of the season, while in fullest vigor, and the reduction in the average rate of progress the farther east and south they extend. The length of their stay depends much upon circumstances. Early in the summer, when they first begin to pour down on the more fertile country, they seldom remain more than two or three days; whereas, later in the season, they stay much longer. In speaking of the advent and departure of these insects, I use relative language only. The first comers, when—after having devoured everything palatable—they take wing away, almost always leave a scattering rear guard behind, and are generally followed by new swarms; and a country once visited presents for weeks the spectacle of the insects gradually rising in the air between the hours of 9 or 10 a. m. and 3 p. m., and being carried away by the wind, while others are constantly dropping.

In short, the rate of spread is greatest during the first 10 or 15 days of their winged existence, or before the females become occupied with egg-laying. The invading insects are then passing the extensive plains and thinly settled regions of the Northwest, where there is little inducement for them to halt, and the rate at such times, with strong and favorable wind, may reach a maximum of from 200 to 300 miles a day.

The rate of spread of departing swarms from the temporary region is very much the same. It is most rapid and direct early in the season when the insects first begin to leave more southern latitudes, and becomes more slack and inconstant as summer advances.

Extended flight does not take place till 4 or 5 days after the first insects become winged. For the first 2 or 3 days the newly-winged individuals mingle with the larvæ and pupæ, eating ravenously and making short flights of a few yards or more, as if to try their wings, recalling fully the habit of native nonmigratory species. Then for a while they rise one by one higher in the air and float along with the wind, and finally, when weather and wind are favorable, all that are strong and mature enough rise as with a common impulse during the warmer morning hours and move off vigorously in one direction until they are soon out of sight. They begin to rise when the dew has evaporated, and generally descend again toward evening. A swarm passing over a country yet infested with the mature insects constantly receives accretions from these, and is, consequently, always more dense in the afternoon than in the forenoon. In rising the insects generally face the wind, and it is doubtful if they could ascend to any great height without doing so.

The velocity of flight, which, for many reasons, is quite distinct from the general movement understood by "rate of spread" or "migration," is naturally greater and will average about 10 miles an hour. It is also greatly dependent on the wind. Mr. S. S. Clevenger, of New Auburn, Minn., gives the average rate at 15 miles for that locality; while the reports of other correspondents give the range from 4 to 40 miles, the more common rates mentioned being 12, 15, and 20 miles per hour. Mr. Brown Lusted, of Winnipeg, Manitoba, tells us that in 1867, when he was traveling from Saint Cloud, Minnesota, to Manitoba, the locusts were moving in the same direction, at from 30 to 35 miles a day. Professor Aughey's observations for 1877 give the rate per hour at 4 miles and upward; but he has himself expressed to us the belief that his estimates are somewhat low. We have ourselves never witnessed them flying so slowly as 4 miles per hour, which must be considered the minimum rate where there is no impediment. When tacking against the wind, they may move not more than 1 mile, while the maximum rate, in a strong wind, may reach as high as 50 miles or more per hour.

Direction of invading Swarms.—While there may be, during an invasion, local flights in all possible directions (except, perhaps, due west), the general movement east of the mountains is conspicuously toward

the south and southeast. The more local and irregular flights are generally made for food, but the more extended southward movements are in obedience to other laws, discussed in Chapter XII of the Report and also on page 250. West of the main Rocky Mountain range the rule of flight appears to be from the higher plains and plateaus, where the insect normally breeds, to the lower and more fertile valleys; and the greater irregularity of the prevailing winds and more broken nature of the country preclude the same regularity in directions of flight that, on the whole, prevails east of the range.

Time of Appearance of invading Swarms.—In endeavoring to deduce general conclusions respecting the time of year that the 1874 swarms reached different parts of the country, great difficulty was experienced in sifting those accounts which referred to the progeny of the 1873 invasion, and those which hatched within the insect's native range, and came from the extreme Northwest. The same was true of the fresh 1876 swarms, and those which hatched in Minnesota.

As a rule, the insects which hatch in the temporary region acquire wings and leave before the fresh swarms from the mountain region appear. In the more northern regions, as in Minnesota and Manitoba westward, the insects hatched on the ground acquire wings the latter part of June and in July. The period is earlier as we go south, until in southern Texas they are able to fly in April. The time of appearance of invading swarms from the permanent region is in inverse ratio, *i. e.*, earlier to the north and later to the south. Thus while on the confines of the permanent region it is almost impossible to distinguish between the insects which hatch there and the fresh swarms from the Northwest, the difference becomes more and more marked toward the south and east.

In 1874, swarms appeared during June in southern Dakota; during July in Colorado, Nebraska, and Minnesota; during the latter part of this month in Iowa and western Kansas. During August they came into southeast Kansas and Missouri; and by the middle of October they reached Dallas, in Texas. In 1876 they came later.

Number of Broods.—Peculiarities of Habit.—The Rocky Mountain Locust, in spite of the fact that a second lot of eggs is sometimes deposited in one season, is essentially single-brooded. This second deposition of eggs generally fails to hatch and arrive at maturity in time to reproduce the species. This follows from the fact that this locust is a sub-boreal insect and attains its greatest perfection only where the winters are long and cold and the summers short. The theory has been advanced that the object of the migrations of this species is to find a suitable region for producing a second brood; for instance, that a brood hatched early in the south moves to the northern limits of its range and brings forth a second brood. But it is a notable fact that in years of disastrous invasion from the northwest in late summer and autumn the locusts have not prevailed in the south during the spring.

Also in years when they hatch and prevail in the temporary region their migration therefrom in early summer is virtually complete and no disastrous incoming swarms visit the same region later in the season. Single-broodedness is then the rule. Where the species has been observed to breed for 2 or 3 consecutive years, as in Minnesota and northerly regions, only one annual generation is produced. Those swarms which reach Manitoba from the south in early summer lay eggs the bulk of which remain unhatched till the following spring. The same was observed in Minnesota in 1873, the eggs laid that year remaining mostly unhatched until 1874. This rule may have exceptions. Many insects are single-brooded at the northerly limit of their range, but double-brooded farther south, and the premature hatching of the eggs of this locust in autumn in southerly regions is a step in this direction. But it has been conclusively shown that it can not establish itself under more southern climatic influences which suit some of its related species, but can breed permanently only under those conditions which induce single-broodedness.

Hibernation.—From the facts just stated it will be seen that the normal hibernation is passed in the egg state. Though many Acridiidae hibernate in the imago or even the pupa state, under bark, logs, or stones, the species under consideration after laying its eggs in the summer lasts until autumn, but dies with the approach of cold weather.

THE LESSER MIGRATORY LOCUST.

(*Caloptenus atlanis* Riley.)

RANGE OF SPECIES.—*C. atlanis*, in common with the next species, *C. femur-rubrum*, has a very extended natural range, breeding annually in abundance from middle Florida nearly to the Arctic circle, in many places entirely replacing the latter species. It becomes less common

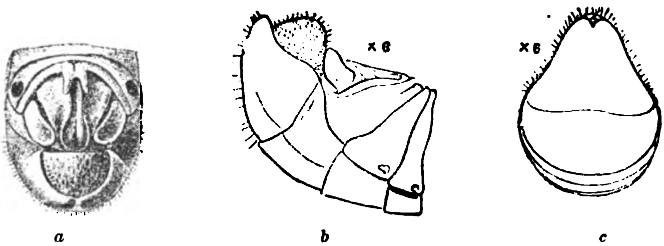

FIG. 4.—*Caloptenus atlanis*, anal characters of male; *a*, from above; *b*, from side; *c*, from above, enlarged six times (after Riley).

towards the Mississippi, *C. femur-rubrum* generally predominating, while it gives way to *spretus* on the great plains. It, however, rather strangely, considering that it is essentially an eastern species, again appears toward the Pacific in the more northern regions extending from about the fortieth parallel in Utah and California as far north as the Yukon River.

Destructive Appearances.—In our annual report for 1883 we gave a full historical account of the destructive appearance of this species, and to this account those who are interested are referred. They have been reported as injurious in 1743, 1746, 1749, 1754, 1797, 1798, 1816, 1821, 1826, 1871, 1872, 1874, 1875, 1877, 1882, 1885, and 1889, in one and another locality in New England. The 1885 appearance was described in the report mentioned, and that of 1889 is treated in *Insect Life*, Vol. II, pp. 66–70. Mr. Bruner, in 1885, found the species numerous about Glendive, Montana, and in many places in the region of the Yellowstone and Missouri Rivers it was twice as numerous as *spretus*.

Life-history and Habits.—The following is from the report for 1885.

In general life history it is in all respects similar to *C. spretus*. It will be unnecessary, therefore, to give here anything beyond the most salient facts.

The eggs and the egg mass are so similar to those of *C. spretus* that there is no other difference than in the somewhat smaller size of either. They are laid just beneath the surface of the ground in precisely the same manner. Each female in the course of her life usually deposits two of these masses, though at St. Louis I have observed instances in which three and even four were placed by the same female. It is in the egg state that the insect passes the winter and the young locusts hatch in the spring. The average period between hatching and maturity we found at St. Louis to be 80 days, or some 10 days longer than in the case of *C. spretus* and *C. femur-rubrum*, but in New Hampshire it is probably somewhat longer.

In about one week after reaching full growth the insects pair, and soon thereafter commence ovipositing. There is undoubtedly but one annual generation in New England, whereas in Missouri we found uniformly two. In the Merrimac Valley the hatching period extends throughout May, and most of the individuals have become winged by the early part of July. Oviposition continues from the latter part of July till frost. Some of the earlier laid eggs hatch in autumn, so that there is the same tendency toward a second brood as we find in *spretus*, a tendency which is more marked during a warm, protracted autumn, and which is beneficial to the farmer, inasmuch as all these autumn-hatched individuals invariably perish during the winter.

THE NON-MIGRATORY RED-LEGGED LOCUST.

(*Caloptenus femur-rubrum* Harr.)

Range of the Species.—This locust has a common range with the preceding species. It breeds from Florida to British America, but is more scarce in the eastern portion of its range while it becomes abundant in the Mississippi Valley. *C. femur-rubrum* is also found with *atlanis* on the Pacific Slope.

Destructive Appearances.—Under this head it can only be said that this locust, being non-migratory, causes only local damage, and few

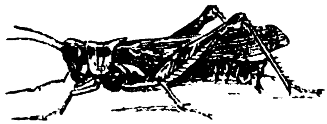

Fig. 5.—*Caloptenus femur-rubrum*—natural size (after Riley).

cases of destructive appearances are to be found recorded. It often increases so as to cause local damage and is yearly more or less abundant throughout its range. In company with the Differential and Two-striped Locusts it frequently gives cause for alarm by devastating grass lands or growing crops. In 1885 it was abundant, with *atlanis*, *spretus*, and local species, about Glendive and in other portions of eastern Montana. In August, 1888, it had, with *bivittatus*, destroyed the oat crop about St. James, in Manitou County, Michigan. Such isolated reports as these come in nearly every year and only show that the species is not capable of concerted damage over any large area.

Life-History and Habits.—These differ little from those of the foregoing species. The female has occasionally been noticed to lay four different egg masses. The period between hatching and maturity was observed at St. Louis to be about 70 days. The species was observed to become winged there about the last of August, and eggs were deposited about the first of October. It is single-brooded.

THE CALIFORNIA DEVASTATING LOCUST.

(*Caloptenus devastator* Scudd.)

Range of the Species.—Scudder records this species as found in California, Nevada, and even sparingly in Colorado. It is, however, essentially a Pacific coast species and is probably to be held accountable for much of the damage attributed in this region to other species. Bruner also records it from the Upper Yellowstone Valley.

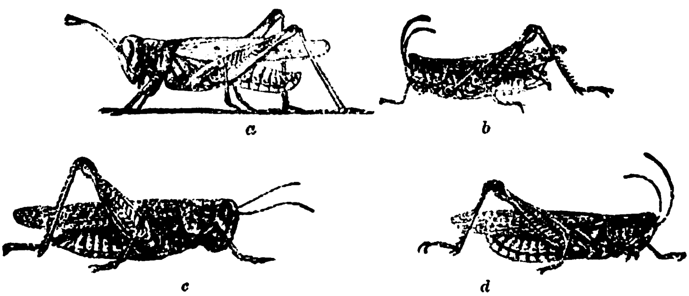

Fig. 6.—*Caloptenus devastator*: *a*, large female from California, 1885; *b*, small female, Reno, Nevada, 1880; *c*, male, Fort Keogh, Montana, 1880; *d*, same as *c*, all natural size (after Riley).

Destructive Appearances.—California has in former years had its locust plague. Many devastating swarms visited the Pacific coast region during the latter half of the last century and the first half of the present, while for 30 years after this period no general destruction was committed. But there is no means of positively identifying these devastations with the species that committed them. The accounts are old, and no descriptions or specimens have been preserved. We can only judge from such later appearances as have furnished us with exact data. It

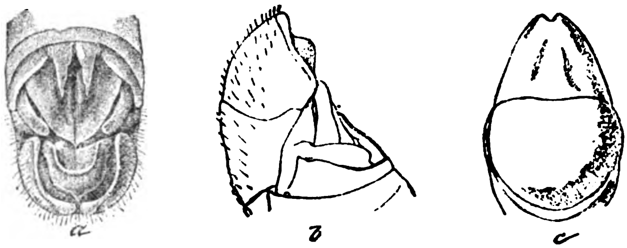

Fig. 7.—*Caloptenus devastator*: anal characters of male; *a*, from above; *b*, from side; *c*, from below—enlarged (after Riley).

is most probable that *C. devastator*, as intimated by Scudder, committed a large, if not the larger, share of these depredations. Accordingly we will, under this species, notice the destructive California appearances, which we give in brief from the first commission report. *Camnula pellucida*, another destructive California species, which is noticed further on, doubtless also assisted in many of these invasions.

In 1722, 1746, 1749, 1753, 1754, 1765, 1767 it appeared in California. (Mr. A. S. Taylor, Smithsonian Report, 1858.) The following, up to 1885, are from the same authority (*l. c.*)

1823. Franciscan Missions of Upper California.

1827 or 1828. "Ate up nearly all the growing crops."

1834 or 1835. "Destroyed the crops of the rancheros and missions, with the exception of the wheat."

1838–1840. For these three years destroyed the crops and gardens about San Francisco and San Rafael.

1846. Corn and frijoles completely consumed on the Salivas Plains. This was a dry year in California.

1852. Near Centreville, Alameda County, California, also in Oregon. They were noticed in the same locality every year since up to 1877, but in very moderate numbers. (Lorenzo G. Yates.)

1855. The most noted year for 10 years on the Pacific coast.—California, Oregon, and Washington Territory. Great damage and many immense flights witnessed in this region.

1856. Lower California small numbers.

1859. Pitt River Valley, California.

1862 or 1863. Horintos, California.

1866 or 1867. Swarm 15 miles wide seen near Stockton, California.

1869. Tulare County, California.

1873. Lower and south California.

1877. Fresno County, California.

1885. San Joaquin Valley of northern California; southern Oregon.

This invasion is known to be due to *C. devastator*, which outnumbered all other species combined in proportion of 7 to 1. The next in abundance was the ash-colored locust, which was only one-twentieth as numerous as the former. Mr. Coquillett's account of this year's invasion is to be found in Annual Department Report for 1885. Mr. Koebele also gives an account in the same report on the locusts about Folsom, California, in 1885, the greater part of which belonged to this species.

LIFE-HISTORY AND HABITS.—The habits of this locust are much the same as those of the preceding species. We have few exact data on this point. The locusts have been found mature and in force early in June. They are generally much more abundant in the foothills along the sides of valleys, and it is probable that these are their usual breeding places. It seemed evident from the 1885 investigations that the locusts did not migrate from a distance, but bred in the vicinity of the plantations; for while the edges of these during the first part of the invasion were well stocked with locusts, there were only a few in the center. Young locusts which were referred to this species were found in some numbers upon uncultivated lands bordering plantations. These waste places are covered with water during the winter, and sometimes until late in summer. When seeding time arrives, they are too wet to be plowed and seeded and thus remain undisturbed. The green vegetation of these waste places furnishes food to the locusts late in the season, when other fields are bare, until the egg-laying season arrives. The subsequent submersion through winter does not seem to affect the vitality of the eggs.

THE DIFFERENTIAL LOCUST.

(*Caloptenus differentialis* Thos.)

RANGE OF THE SPECIES.—This locust ranges through Illinois, Missouri, Nebraska, Kansas, and Iowa. It is also found in Indiana, Texas, New Mexico, and California.

DESTRUCTIVE APPEARANCES.—This and the following species are much larger than the preceding ones, and though like *C. femur-rubrum* they do not possess the migratory habit, they can and occasionally do

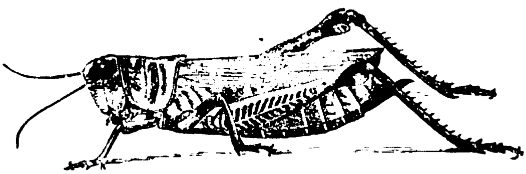

FIG. 8.—*Caloptenus differentialis*, natural size (after Riley.)

make considerable flights. We have devoted some space in the first report of the commission to accounts of damage by this species. It was abundant in 1875 in central Illinois and attracted considerable attention. It was accompanied by the Red-legged and Lesser Migratory

Locusts. In 1877 it became abundant in a restricted locality near Socorra, New Mexico, and in 1885 this species was noticed rather abundantly in company with the Devastating Locust in the San Joaquin Valley in California, occuring in about the proportion of one Differential Locust to twenty-five Devastating Locusts.

LIFE-HISTORY AND HABITS.—In the vicinity of St. Louis, Missouri, the first specimens of this locust were observed to become winged July 19. Eggs were laid September 9. As a deviation from the usual egg-laying habits of the genus, it is an interesting fact that the eggs are sometimes very numerously placed under bark of logs that have been felled on low land. The eggs of this species, unlike those of *spretus*, *atlanis*, and *femur-rubrum*, are not quadrilinearly but irregularly arranged. This irregular arrangement also occurs in the egg-masses of *Schistocera americana* and *Ocdipoda phanœcoptera*. The head ends of the eggs in the pods point mostly outward. One hundred and seventy-one eggs have been counted in a single mass.

Mr. Coquillett has made some interesting observations on the life history and habits of this species, which will be found in the 1885 report. They acquired wings from the last week in June to the last week in July, and began laying eggs July 23. A single female occupied 75 minutes in depositing an egg mass. The situation chosen for egg-laying was invariably the edge of one of the basin-like hollows at the foot of a tree. This locust is not easily startled, and its ordinary flight is rather heavy, and sustained only for a distance of 12 to 20 feet. Mr. Coquillett found it principally in trees, and it seemed to be particularly fond of the leaves of the poplar. He did not find it in grain fields, but it was numerous in fields of alfalfa. Mr. Webster has noticed this insect gnawing the limb of an apple tree at Princeton, Ind.

THE TWO-STRIPED LOCUST.

(*Caloptenus bivittatus* Scudd.)

RANGE OF SPECIES.—This species has a very extended range, being found from Maine to Utah and California and extending as far South as Carolina, Mississippi, and Texas.

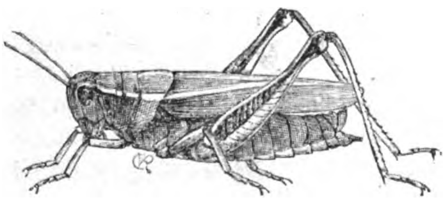

FIG. 9.—*Caloptenus bivittatus*, natural size (after Riley.)

DESTRUCTIVE APPEARANCES.—This locust is distinguished from the last-named species in having two lateral yellowish stripes from the head

to the extremities of the wing covers. (Fig. 9.) Like the last, it sometimes assists in migratory flights with *C. atlanis* and *C. femur-rubrum.* It often becomes locally abundant enough to do much damage to crops. In 1877 Mr. Theo. M. Finley, writing from Niles, Michigan, sent us specimens with the statement that they did considerable damage near Berrien Springs, Michigan, though confined to a territory of only a mile square. Grass and oats suffered most, the last crop being entirely destroyed. At Fort Wallace, Kansas, in July 1877, this locust was common while *C. spretus* was rare. Other occasional cases of damage have been reported, but these are only local occurrences. It does not increase in sufficient force to spread over any large tract of country.

LIFE HISTORY AND HABITS.—We have observed this locust pairing in Missouri from the 8th of July to the 18th of August. The first winged insects were noticed July 7. Females were confined in cages through July and August, but no eggs were deposited until August 31. Eggs kept indoors hatched the last of December.

Those kept outdoors began to hatch the middle of March. A gravid female opened in September was found to contain 79 eggs.

THE PELLUCID LOCUST.

(*Camnula pellucida* Scudd.)

RANGE OF SPECIES.—Synonym: *Œdipoda atrox.* It occurs in California, Utah, Wyoming, Colorado, New Mexico, Montana, Dakota, and in the East in Maine, Massachusetts, Vermont, Connecticut. These Eastern and Western forms were formerly supposed to be two distinct species, the name *atrox* being applied to the Western specimens and *pellucida* to the Eastern; but they have been found to show no appreciable differences, and must be considered the same species.

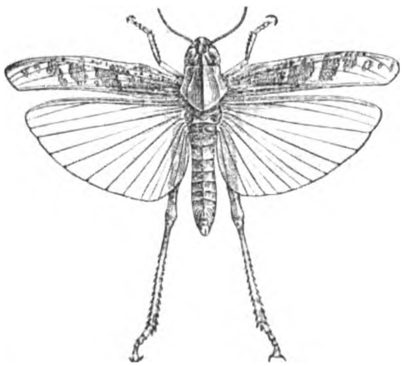

FIG. 10.—*Camnula pellucida*—natural size (Emerton *del*).

DESTRUCTIVE APPEARANCES.—Some of the destructive locust years tabulated under *Caloptenus devastator* may have been due to *Camnula pellucida*, as the two species have doubtless been confused in these invasions. This species, however, is known definitely to have occurred in devastating migratory swarms in California in 1878, particularly in the Sierra Valley, and deposited its eggs by millions on ranches hitherto unvisited by them, thus menacing an immense area of country.

In the previous year, 1877, they ravaged the California coast from Point Conception to Santa Barbara. In 1879 they were again abun-

dant, the numerous eggs deposited in 1878 having developed still greater swarms.

In 1885, according to Bruner, it had become very numerous in the Yellowstone and upper Missouri Valleys, having developed in numbers very rapidly in the preceding 5 years. In this year, in company with *C. spretus* and *C. atlanis*, it did the principal injury in this region to vegetables and grain, while the other native species attacked the grasses.

LIFE-HISTORY AND HABITS.—This is the only North American locust of the subfamily to which it belongs (*Œdipodinæ*) that is migratory. All the other locusts mentioned in this bulletin belong to another subfamily (*Acridiinæ*). This locust is not a truly migratory species, as its swarms do not rise to a great height or remain long in the air, but has rather assumed the migratory habit in comparatively recent times. Eggs received from California hatched in large numbers the last of April and again in May.

THE AMERICAN ACRIDIUM.

(*Schistocerca americana* Scudd.)

RANGE OF SPECIES.—This is much larger than any of the preceding species, being in fact our largest locust, often measuring more than 2½ inches in length. It occurs throughout the Southern States from the District of Columbia to Texas, and extends south through Mexico into Yucatan and Central America. It is also found as far north as Illinois and Indiana, and is doubtfully reported from New York.

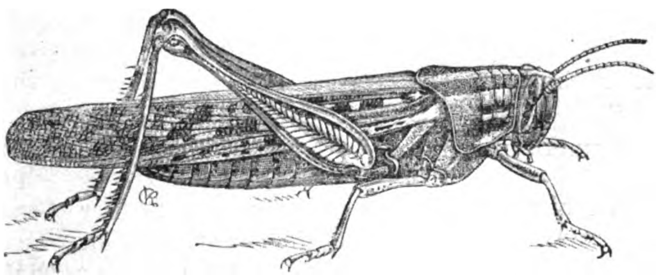

FIG. 11.—*Schistocerca americana*—natural size (after Riley).

DESTRUCTIVE APPEARANCES.—This species was very abundant in 1876 in Missouri, Tennessee, Indiana, Ohio, North Carolina, Georgia, and swarm seven reach Virginia. They caused much devastation, devouring in many places every green thing, even alighting on trees, and caused much alarm. They were supposed to be the Western species (*spretus*) advancing east. They present a more imposing appearance, from their great size, than the Rocky Mountain species, but can not cause such great destruction, as they are generally sedentary within the bounds of the United States, while to the south, in Yucatan and other parts of Central America, they are said to possess the true migratory habit.

LIFE-HISTORY AND HABITS.—I have found the eggs deposited June 24, and obtained the newly hatched larvæ July 27. The arrangement of the eggs is somewhat different from those of other Acridiinæ which have come under my observation, being arranged in such a manner that the head of all the eggs is directed towards the inner or concave side of the pod. They have nearly the same shape as those of *spretus*, are of about the same color, though larger in size and sparsely covered with a crimson cement which binds them together. The pod is about 1½ inches in length by three-eighths of an inch in diameter and nearly straight. The spongy top of the pod is yellowish white. In one of these pods 120 eggs have been counted. They are usually deposited in grassy plots and the average time between hatching and maturity is about 70 days.

REMEDIES AND DEVICES FOR THE DESTRUCTION OF LOCUSTS.

The matter which follows, although originally prepared with reference only to the Rocky Mountain Locust (*Caloptenus spretus*) will apply almost equally well to the other species mentioned in the preceding pages. As applying to the Rocky Mountain Locust the means recommended for its destruction will apply more especially to the Temporary region, while the suggestions as to prevention apply to the Permanent region, and the reader will readily determine which of the means mentioned are applicable to the local or non-migratory species.

The means to be employed fall very naturally into five divisions: (1) Encouragement of natural agencies. (2) Destruction of the eggs. (3) Destruction of the young or unfledged insects. (4) Destruction of the mature or winged insects. (5) Preventive measures.

ENCOURAGEMENT OF NATURAL AGENCIES.

While little practically can be done by man to further the multiplication of the more minute enemies of the locust, much may be done to protect and to promote the multiplication of the larger animals, especially the birds. These should be protected by most stringent laws, firmly carried out, restraining the wanton destruction too often indulged in by sportsmen and others. Some of the states interested in this question have of late years passed good laws for the protection of these feathered friends, but the laws are, unfortunately, too often a dead letter for want of enforcement. One of the most effectual and successful ways of protecting and encouraging many of the smaller birds is to offer a reward for hawks. This has been done with very beneficial results in Colorado, and other states would do well to follow her example.

DESTRUCTION OF THE EGGS.

The destruction of the eggs has been followed, in the older countries of the East, since Pliny's time, and has long been recognized in Europe and Asia as one of the most efficacious means of averting locust injury. These eggs are laid in masses, just beneath the surface of the ground, seldom to a depth of more than an inch; and we have already considered the character of soil and the sites preferred by the females in laying them. In years like 1874 and 1876 we have known favorable locations, for many hundreds of square miles, so thickly supplied with these eggs, that scarcely an inch of the soil could be stirred without exposing them. As a rule, the dead bodies of the locusts strewn about the ground in autumn are a good indication of the presence of eggs in such ground, though the eggs may often be abundant without this indication. The means to be employed in destroying locust eggs may be considered under the following divisions: (1) Harrowing; (2) Plowing or spading; (3) Irrigation; (4) Tramping; (5) Collecting.

(1) HARROWING IN THE AUTUMN.—Harrowing in the autumn, or during dry, mild weather in early winter, will prove one of the most effectual modes of destroying the eggs and preventing future injury, wherever it is available. It should be enforced by law whenever the soil in any region is known to be abundantly stocked with eggs. A revolving harrow or a cultivator will do excellent service in this way, not only in the field, but along roadways and other bare and uncultivated places. The object should be, not to stir deeply, but to scarify and pulverize as much as possible the soil to about the depth of an inch. Where the cultivator is used, it would be well to pass over the ground again with a drag or a brush harrow for this purpose. Some of our correspondents have urged, and with some reason, that wherever land can conveniently be prepared to induce the females to oviposit in it, as by plowing and then rolling when the insects are beginning to breed, such preparations should be made. A subsequent harrowing will be the more easy. In practice, this method will not often be adopted, because it will pay only under exceptional circumstances.

(2) PLOWING.—Next to harrowing this is one of the most generally available means possessed by the farmer of dealing with locust eggs.

The actual experience is somewhat conflicting, and in some light, dry soils a good number of them will hatch late if turned under a foot; yet, from our own observations, and a vast amount of experience gathered together, we recommend it as profitable. If delayed till spring, it should be done just as the young begin to hatch, as it is then most effectual. The plowing will be effectual according as the soil is porous or tenacious, *and according as the surface is afterward compressed by harrowing and rolling.* From the experiments recorded in the first report of the commission, it is obvious that, all other things being equal, a plowing of 4 to 6 inches will prove more effectual in spring, if the ground be

subsequently harrowed and rolled, than deeper plowing with no subsequent comminution and compression.

(3) IRRIGATION.—This is feasible in much of the country subject to locust ravages, especially in the mountain regions, where, except in exceptionally favorable locations, agriculture can be successfully carried on only by its aid, and where means are already extensively provided for the artificial irrigation of large areas. Where the ground is light and porous, prolonged and excessive moisture will cause most of the eggs to perish, and irrigation in autumn or in spring may prove beneficial. Yet the experiments recorded in the commission reports prove that it is by no means as effectual as had been generally believed, and as most writers had previously assumed to be the case.

In fact these experiments gave us very little encouragement as to the use of water as a destructive agent, and we can readily understand how eggs may hatch out, as they have been known to do, in marshy soil, or soil too wet for the plow; or even from the bottom of ponds that were overflowed during the winter and spring. While a certain proportion of the eggs may be destroyed by alternately soaking and drying the soil at short-repeated intervals, it is next to impossible to do this in practice during the winter season as effectually as it was done in the experiments; and the only case in which water can be profitably used is where the land can be flooded for a few days just at the period when the bulk of the eggs are hatching.

(4) TRAMPING.—In pastures or in fields where hogs, cattle, or horses can be confined when the ground is not frozen, many if not most of the locust eggs will be destroyed by the rooting and tramping.

(5) COLLECTING.—The eggs are frequently placed where none of the above means of destroying them can be employed. In such cases they should be collected and destroyed by the inhabitants, and the State should offer some inducement in the way of bounty for such collection and destruction. Every bushel of eggs destroyed is equivalent to a hundred acres of corn saved, and when we consider the amount of destruction caused by the young, and that the ground is often known to be filled with eggs; that, in other words, the earth is sown with the seeds of future destruction, it is surprising that more legislation has not been had looking to their extermination.

One of the most rapid ways of collecting the eggs, especially where they are numerous and in light soils, is to slice off about an inch of the soil by trowel or spade, and then cart the egg-laden earth to some sheltered place where it may be allowed to dry, when it may be sieved so as to separate the eggs and egg-masses from the dirt. The eggs thus collected may easily be destroyed by burying them in deep pits, providing the ground be packed hard on the surface. In the thickly settled portions of Europe, where labor is abundant and cheap, this method may be adopted with some advantage, but it will scarcely be employed in this country, except as a means of earning a bounty, when, in the

more thickly settled sections, it will prove beneficial and give employment to young people and others who have nothing else to do.

DESTRUCTION OF THE YOUNG OR UNFLEDGED LOCUSTS.

In the destruction of the young, no methods that will not sweep them away in wholesale fashion have any value for our western farmers, however valuable they may be to the owner of a small flower or truck garden. It is for this reason that we have been able to profit so little by European methods, and have had to invent means suitable to our broad western fields and the extensive nature of our farming operations. The best that most European authors can advise is the killing of the insects with flattened implements or brush; while Gerstäcker and other writers devote page after page to prove the superiority over other methods of catching the insects with hand-nets—a method which, while doubtless of some utility in dense German settlements, would prove absolutely futile on our large and scattered prairie-farms and against the excessive numbers of the pests which our farmers have to deal with. While, therefore, we shall mention all available means that have been or may be employed, we shall devote more especial attention to those which are useful in a broad and general way in the field.

Experience has shown that the results of any particular measure will vary in different regions, dependent, to some extent, upon the nature of the soil, the condition of the crops, and the general characteristics of indigenous vegetation. Circumstances may also render some particular measure available and profitable to one farmer where it would be unprofitable to another. For convenience, the means of accomplishing the desired result may be classified into: (1) Burning, (2) crushing, (3) trapping, (4) catching, (5) use of destructive agents.

(1) BURNING.—This method is, perhaps, the best in prairie and wheat-growing regions, which compose the larger part of the area subject to devastation by this locust. In such regions there is usually more or less old straw or hay which may be scattered over or around the field in heaps and windrows, and into which the locusts, for some time after they hatch, may be driven and burned. During cold or damp weather they congregate of their own accord under such shelter, when they may be destroyed by burning without the necessity of previous driving. Much has been said for and against the beneficial results of burning the prairies in the spring. This is chiefly beneficial around cultivated fields or along the roadsides, from which the locusts may be driven, or from which they will of themselves pass for the shelter the prairie affords. Scarcely any eggs are laid in rank prairie, and the general impression that locusts are slaughtered by myriads in burning extensive areas is an erroneous one, at least in the temporary region.

In burning extensive prairies after the bulk of the locusts hatch, the nests and eggs of many game birds are destroyed; but as the birds themselves escape destruction on the wing, they may and do return and

nest again, while, on the contrary, many injurious insects, like the chinch-bug, for instance, are killed; so that, even leaving the locust question out of consideration, the burning proves beneficial by exterminating other noxious insects, and has some advantages from an agricultural point of view.

As locusts disperse more and more from their hatching-grounds into the prairie as they develop, burning the grass in spring is beneficial in proportion as it is delayed.

Machines for burning have been used in several localities with considerable success. Mr. J. Hetzel, of Longmont, Colo., has employed a machine drawn by horses. It is 12 feet long, from 2 to 2½ feet wide, made of iron, and set on runners 4 inches high. An open grate on the top of the runners is filled with pitch-pine wood, a metal sheet covering the grate to keep the heat directed downward. The grate is generally made with a net-work of heavy wire, such as telegraph wire. Two men and a team can readily burn from 10 to 12 acres a day and kill two-thirds of the insects, but for this it requires a hot fire.

Mr. C. C. Horner gives a more detailed description in the *Colorado Farmer* of a machine of somewhat similar construction:

> It consists of three runners, made of 2 by 4 scantling, 3 feet in length, to be placed 6 feet apart, making the machine 12 feet wide; runners to be bound together by three flat straps or bars of iron (the base being 12 feet long). Across the top, bars of iron hold the runners firmly together, and form a frame across which wire can be worked to make a grate to hold fire. The upper part of the runners should be hollowed out so that the grate may slide along within 2 inches of the ground. A sheet-iron arch should be set over this grate to drive the heat downward. This machine is very light, and can be worked with one horse. Pitch wood is best adapted to burning, and can be chopped the right length and size and left in piles where most convenient when needed. This machine is intended to be used when the little 'hoppers just make their appearance along the edge of the grain, going over the ground once or twice each day, or as often as necessary to keep them killed off. The scorching does not kill the grain, but makes it a few days later. This is cerainly the cheapest as well as the most effectual manner of getting rid of this pest.

Hand burners, consisting of any form of pan or grate, or wire sieves, with handle attached, to hold combustible material, will do excellent service in gardens and small inclosures.

There is another method by which large numbers of locusts can be burned, consisting merely of a bundle of rags or tow, which, after being attached to long wire or iron rods and saturated with kerosene, can be ignited and carried over the field. This method has been quite satisfactorily used in Colorado. A stout wire, say 40 feet long, is thoroughly enveloped in rags soaked in coal oil. A small wire is wound around the rags to keep them in place, and the simple device is complete. Two men carry this rope, after setting fire to the rags, across the field to and fro until the fuel is exhausted, and as it is not necessary to pass over the same ground more than once or twice, a large field of grain can be thus protected during the half hour or so that the rags burn. The effect is that of a miniature prairie fire.

Under this head may be mentioned a machine constructed by Mr. Kimball C. Attwood, of Syracuse, New York (patent No. 193,105, dated July 17, 1877), for destroying the insects by sulphur fumes. The machine is too expensive and complicated to come into general use, especially as it is less effectual than some of the simpler ones. The principle of the invention consists in attaching to the axle of the machine a light stove and connecting the same with a blower or bellows by means of a tube. Surmounting this tube, and close to the stove, is situated the hopper for the reception of the destroying compound (sulphur), while the lower section of the stove is connected with an escape-pipe having attached thereto a series of flexible tubes, by means of which the fumes of the compound are carried to the ground. Attached by suitable means to the rear of the axle is a horizontal bar, to which is secured the apron or cover designed to prevent the escape of the fumes after being delivered by the flexible tubes.

Other machines have been constructed, having troughs or wire receptacles attached, in which the locusts are deposited and ultimately destroyed by means of sulphur fumes or hot water. But as these remedies are applied by hand, they will be classed under the head of *Catching*, etc.

(2) Crushing.—The satisfactory destruction of locusts by this means can only be advantageously accomplished where the ground is smooth and hard. Where the surface of the ground presents this character, heavy rolling can be successfully employed, especially in the mornings and evenings of the first 8 or 10 days after the newly hatched young have made their appearance, as they are generally sluggish during those times, and huddle together until after sunrise. It is also advantageously employed during cold weather at any time of day, since the young when the temperature is low seek shelter under clods, etc. In various parts of Europe and Asia flat, wooden, spade-like implements are extensively used for crushing young locusts. Large brushes, weighted down with stone and drawn by horses, were in some instances used last summer, but with less success than was anticipated.

Several machines, most of them patented, were for the first time used during the past year to further the crushing of the young, and while none of them are likely to take the place of the more simple methods of catching, to be presently described, we nevertheless feel that it devolves upon us to describe some of them. That represented on Pl. I was invented by Mr. George B. Drum, of Syracuse, Nebraska (patent No. 187,258, dated February 13, 1877). Fig. 7 is a vertical section on line *x*. Fig. 6 is a plan view with a part of the top removed, showing the mechanism.

Another is that invented by Mr. Michael H. Simpson, of Boston, Massachusetts (patent No. 198,420, dated December 18, 1877). Pl. II, Fig. 1, represents a perspective view of the machine; Pl. II, Fig. 2, a sectional view of the same as shown in the preceding; and Pl. II, Fig. 3, a sectional view of the same arranged for the removal of the insects.

Another machine that may be mentioned in this connection is that invented by Mr. Charles Hoos, of Arago, Nebraska (patent No. 187,155, dated February 27, 1877). In the accompanying illustrations, Pl. II, Fig. 4, represents a top view of the machine; Pl. II, Fig. 5, is a vertical section of the same taken through the line *x x;* and Pl. III, Fig. 1, is a side view.

I witnessed the working of a machine invented by Mr. T. K. Hansberry, of Padonia, Kansas (patent No. 188,359, dated March 13, 1877), intended to crush the insects by means of movable wooden bars. It does not prove very successful, however, except on the very smoothest ground. Pl. III, Fig. 2, is a top view, when mounted on wheels or runners; Pl. III, Fig. 4, represents the front. Pl. III, Fig. 3, is a sectional view of the machine when on runners, with knives or bars attached; and Pl. III, Fig. 5, shows the slide attached, close to the axle, to close the angle formed at the side by the ground and the knives or bars when the machine is mounted on wheels.

Mr. Elisha Kenworthy, of Walnut, Iowa, has invented a machine (patent No. 186,970, dated December 5, 1876) which can be placed under this class of machines. Pl. III, Fig. 7, presents a vertical section of the invention, and Pl. III, Fig. 6, a plan view of the same.

Numerous communications upon this subject have been received, some of which, if not all, are or may have been successful on a small scale. Others, if carried out, and the contrivances built and given a fair trial, might be of especial benefit.

Mr. J. C. Melcher, of O'Quinn, Tex., constructed one which he describes as follows:

It is constructed on the hand lawn-mower style, mounted on light wheels, a disturbing rim, 8 or 10 feet long, passing low over the ground to stir the 'hoppers up. Just behind the disturber are two sheet-metal rollers, one of which drives an endless band. As soon as the 'hoppers jump over the disturber, the band catches them and crushes them between the rollers. The rollers, being of sheet-iron, are elastic enough to press uniformly at any given point. A rack of wire web or cloth ascends over the top of the machine to prevent the 'hoppers from escaping. It is operated by two men pushing the machine before them.

Mr. John Wise, of Nebo, Platte County, Nebraska, says (in a letter dated May 26, 1877) "a good machine can readily be made by having two revolving rollers mounted on wheels, the rollers to be 4 or 6 inches above ground, so arranged, if need be, to be adjusted either higher or lower, the upper to revolve on the top of the lower," etc. To a contrivance of this sort handles could be attached for pushing, and, with the addition of a frame covered with cloth or muslin, projecting forward and outward.

In addition to the preceding contrivances for crushing locusts is one invented by Mr. F. Peteler, of Minneapolis, Minnesota.

Pl. IV represents a front view, and Pl. V, Fig. 1, a side view, of the same machine.

In a communication from the inventor, dated June 8, 1877, the follow-

ing description is given: The machine is intended to be drawn by horses, the drawing representing one to be drawn by a team. "The frame is mounted upon two wheels. The front is a sheet-iron platform, over which revolves an elevator made of slats, which carry the locusts into boxes, where they pass between rollers, are crushed, and fall to the ground. The sides and top or back are wire screws, the whole forming a scoop 16 feet long (on the bottom 19 feet), 8 feet high, the top of which can be lowered or raised according to the height of the grain or grass."

A more detailed description follows:

AA, driving-wheels; B, guiding-wheel; D, setting-lever; *d*, retaining-post; G, endless carrier; H*h*, gearing for elevator and crushing-shaft; I, crushing-rollers; L, set-screw to spiral spring; *l*, spiral spring to press rollers together when necessary; N, slats on endless chain with sheet-iron projections to hold the locusts; M, drag-chain (or strips of light wood) to stir the locusts.

Mr. Peteler believes that, with a single-horse machine, 40 or 50 acres can be gone over in a single day, and by changing horses more can be done; but we, unfortunately, had no opportunity to test the practical working of the machine, as, by the time it was perfected, simpler and satisfactory methods were extensively being employed in Minnesota, and the inventor did not feel encouraged to manufacture his machine. Indeed, its expense is too great to warrant its manufacture, except to order by clubs of farmers. To use Mr. Peteler's own words: "This machine is intended for local or State authorities to use on uncultivated lands adjoining farms and unsettled prairies, in order to destroy the insects during the entire season; for that purpose there should be proper organization, with camp outfit, etc., to follow up the swarms, loading the machines on wagons, and battle with the 'hoppers morning and evening, when they are comparatively sluggish. These machines are not designed as temporary contrivances, believing that we shall have the scourge several seasons in some parts of the State, and they should be made strong and durable." Instead of paying bounties from the State treasury for the locusts, Mr. Peteler would have the State aid the farmers by investing in these machines. "Fifty thousand dollars advanced to farmers will place, at $40 each, 1,250 one-horse machines in their hands to keep their grain-fields clear. If they use them only 60 days during the season, and go over only 40 acres per day, destroying but one-half bushel per acre (frequently they would destroy 8 to 10 bushels per acre), they would send 25,000 bushels daily, or 1,500,000 in 60 days, where bad 'hoppers go. That money would be returned to the State in 4 to 6 months by the farmers, provided the State and local authorities will do their duty by destroying the pests on uncultivated lands."

Under this head we may mention the curious suction-fanning machine invented by Mr. J. A. King, of Boulder, Colorado, and one of which, purchased by Mr. T. C. Henry, of Abilene, Kansas, we had the

opportunity to fully test. It consists of two large tin tubes (Pl. v, Fig. 2, AA), about 8 inches in diameter, with flattened, expanded, and lipped mouthpieces, B, running near the ground. This horizontal opening or mouth is about 7 feet long. The tubes connect at the upper extremity with a chamber, C, in which is a revolving fan which makes about 1,200 revolutions per minute. The tubes and fan, with the gearing, are placed in a frame, D, 5 by 10 feet, mounted upon two large driving wheels. EE Pl. VI represents this machine in operation.

The air current made by the revolving fan creates a suction at the mouth, which draws the insects up the tubes and into the chamber. They are then thrown by the fan upon a wire screen, and from thence drop into a kind of hopper which conducts them to a bag. The wire screen rapidly chokes up and must be frequently cleaned. Most of the locusts are crushed and mangled by the rapidly revolving fan, so that the screen may be removed entirely and the locusts thrown out behind. This allows a freer draft and causes a greater suction. This machine can be made for about $50, and it works well on smooth ground or in a wheat field while the wheat is yet short. It is somewhat difficult to keep the lips close enough to the ground. The principle of the machine is a good one, and we see no reason why some cheaper modification of it should not be quite generally used early in the season, especially in Colorado, where there is so much hard, smooth ground around the cultivated fields. The lips might be protected and rendered less liable to bend and get out of order by moving on runners made to extend some distance in front.

Finally, a machine which we saw in Colorado, and which was put up by J. S. Flory, of Greeley, Colorado, is worthy of mention in this connection; for, while it may be used with coal-tar, it is essentially a catching and crushing machine. The Colorado Sun thus speaks of it:

The main feature of this invention is a revolving platform of heavy canvas or wire cloth, which runs between two horizontal rollers. Long arms reach forward, which support a revolving reel; from these arms downward extend sheet-iron sides, over the top a canvas covering; all so constructed as to form a large wide mouth, into which the 'hoppers are driven by the arms of the revolving reel and carried between the two rollers and crushed. Horizontal strips running along the rollers serve to keep the rollers and platform clear of the crushed grasshoppers. The whole machine is supported on two main wheels about the middle and two smaller ones in front. Extending back is a frame or cross-bar, to which one or two horses may be hitched to push the machine forward, or it may be operated by hand. The front of the platform runs close to the ground, and by bearing down at the rear by the driver it can easily be lifted over any obstruction that may be in the way. The machine can be raised or lowered in front to suit the crop over which it is run.

This invention will destroy the grasshoppers without the necessity and expense of using oil or tar. The patent, we understand, also covers the combinations of a receptacle immediately under the rollers, into which the grasshoppers are carried, and in which, if need be, water and oil may be kept, and also a long narrow hopper (just over the rollers), into which coal-tar may be put and allowed to run through onto the platform, thus making it a *self-tarring machine.* Either of these combined methods of destroying the 'hoppers may be used as the farmer may choose. The

machine is so simple in construction that any ordinary workman can put them up at a comparatively small price. The machine may be made of any size desired, from a small hand-machine to one a rod or more in width.

Pl. IX, Fig. 2, represents a front view of this machine when in operation, and Fig. 3 a side view of the frame.

(3) TRAPPING.—This can be easily accomplished, especially when the locusts are making their way from roads and hedges. The use of nets or seines, or long strips of muslin, calico, or similar materials, converging after the manner of quail nets, has proved very satisfactory. By digging pits or holes 3 or 4 feet deep, and then staking the two wings so that they converge toward them, large numbers may be secured in this way after the dew is off the ground, or they may be headed off when marching in a given direction. Much good can be accomplished by changing the position of the trap while the locusts are yet small and congregate in isolated or particular patches.

Ditching and *trenching* properly come under this head; and both plans are very effectual in protecting crops against the inroads of traveling schools of the insects. They were found especially advantageous in much of the ravaged country in 1875, where there was little or no hay or straw to burn. They are the best available means when the crops are advanced, and when most of the other destructive methods so advisable early in the season can no longer be effectually used. Simple ditches, 2 feet wide and 2 feet deep, with perpendicular sides, offer effectual barriers to the young insects. They must, however, be kept in order, so that the sides next the fields to be protected are not allowed to wash out or become too hard. They may be kept friable by a brush or rake.

The young locusts tumble into such a ditch and accumulate and die at the bottom in large quantities. In a few days the stench becomes great, and necessitates the covering up of the mass. In order to keep the main ditch open, therefore, it is best to dig pits or deeper side ditches at short intervals, in which the locusts will accumulate and may be buried. If a trench is made around a field about hatching-time, but few locusts will get into that field until they acquire wings, and by that time the principal danger is over, and the insects are fast disappearing. If any should hatch within the inclosure, they are easily driven into the ditches dug in different parts of the field. The direction of the apprehended approach of the insects being known from their hatching locality, ditching one or two sides next to such locality is generally sufficient, and when farmers join they can construct a long ditch which will protect many farms.

Where the soil is tenacious and water can be let into the ditches so as to cover the bottom, they may be made shallower and still be effectual. The width and depth of the ditch is important, and as experience differed somewhat, I have been at pains to get the experience of a large number of correspondents addressed by circular. Many have success-

fully used ditches 2 feet deep and 18 inches wide; a few have made them only 18 inches by 18 inches. Those who have used water found 12 inches by 15 inches sufficient, while the larger number used a ditch such as I have recommended, viz, 2 feet deep by 2 feet wide, with perpendicular sides. Having been the first to recommend proper ditching in this country, I have felt particular interest in its results, and have been in no small degree amused at the fault found with my recommendation by those who, through slovenly made ditches or other causes, have not been successful in this mode of warfare. It is less effectual against the newly-hatched young, which more easily crawl up a perpendicular bank than the larger ones, and its efficacy will vary with the nature of the soil and other circumstances; for, in proportion as the soil is loose, and the ditches hence apt to fill up by the action of strong winds, or in proportion as strong winds carry the insects over, ditching will necessarily fail.

Those who, from theory rather than from experience, are skeptical about the efficacy of ditching, urge that the locust, especially in the pupa state, can hop more than 2 feet. In truth, however, whether when traveling in a given direction of their own accord, or when being driven or disturbed, they very seldom leap that distance, as all who have had experience well know. That, on a pinch, the pupa can leap even farther, is true; but the fact remains that in practice *Caloptenus spretus* seldom does. So the Chinch Bug, though capable of flight, will yet tumble into a ditch by myriads rather than use its wings. Even the larger winged Acridia and Œdipodæ tumble into such a ditch, and seldom get out again. I would remark in this connection, also, that a ditch 3 feet wide, unless correspondingly deep, will be more apt to permit the insects to escape, when once in, than a narrower one. In hopping, the more perpendicular the direction the insects must take, the shorter will be the distance reached.

The efficacy of the ditch depends not so much on the inability of the young locusts to jump or scale it, as on their tendency not to do so. In the bottom of the ditch they soon become demoralized, crippled, and enfeebled by constant effort and the trampling and crowding upon one another.

Protection by Barriers.—Where ditches are not easily made, and where lumber is plentiful, a board fence 2 feet high and with 3-inch batten nailed to top on side from which the locusts are coming, the edge of it smeared with coal tar, will answer as an effectual barrier and prove useful to protect fields or gardens.

A modification of this method was used with great success in 1883 and subsequent years in the Isle of Cyprus. The "Cypriote system," as it has been called, consists of a series of traps and screens. The screens are made of light hemp canvas, 50 yards long and 2 feet 6 inches wide. Near the upper edge of the canvas is sewn a strip of oil-cloth 4 inches wide. The screens are fixed to stakes of hard wood firmly

driven into the ground at intervals of 13 feet 6 inches, slightly inclined towards the direction from which the attack of locusts is expected. A cord is stretched from stake to stake. The screens are tied to the inside (locust side) of the stakes and to the cords by tapes. About 6 inches in width of the lower edge of the canvas is folded on the ground inside the stakes and weighted with earth. Pits are dug at intervals of generally from 40 to 50 yards, and the usual size of the pits is 6 feet long, 2 feet 3 inches wide, and 3 feet deep. Round the edges of the pit is fixed the trap, consisting of four strips of zinc 9 inches wide. The screens having been so fixed as to head the advancing army of locusts, they march until their progress is stopped by the screen. They climb up the canvas until they reach the oilcloth, which they can not pass. They then descend and crawl to one side or the other until they fall into the pits, from which they attempt to escape by climbing up the sides until they encounter the zinc sheets which project 4 inches from the edge. They then fall back into the pit and when this is full to within about 9 inches of the brim earth is shoveled in to bury the locusts, a new pit having been excavated in the meanwhile to one side. The trap is removed to the new pit, and the same thing is repeated until the whole swarm has been destroyed. The use of this system has practically rid Cyprus of the locust plague, and has also been of great avail in Algeria after other methods had failed.

Coal Oil.—The use of coal oil and coal tar may best be considered in this connection, as both substances are employed in various ways for trapping and destroying the insects. As we shall presently see, in considering the different available destructive agents, coal oil is the very best and cheapest that can be used against the locusts. It may be used in any of its cruder forms, and various contrivances have been employed to facilitate its practical application. The main idea embodied in these contrivances is that of a shallow receptacle of any convenient size (varying from about 3 feet square to about 8 or 10 by 2 or 3 feet), provided with high back and sides, either mounted upon wheels or runners, or carried (by means of suitable handles or supporting rods) by hand. If the "pan" is larger than, say, 3 feet square, it is provided with transverse partitions which serve to prevent any slopping of the contents (in case water and oil are used), when the device is subjected to any sudden irregular motion, such as tipping, or in case of a wheeled pan, when it passes over uneven ground. The wheeled pan is pushed like a wheelbarrow; the hand-worked pan is carried by long handles at its ends. On pushing or carrying, as the case may be, these pans, supplied with oil, over the infested fields, and manipulating the shafts or handles so as to elevate or depress the front edge of the pan as may be desired, the locusts are startled from their places and spring into the tar or oil, when they are either entangled by the tar and die slowly, or, coming in contact with the more active portion of the oil, expire almost immediately. In Colorado they use it to good advantage on the water in their irrigating

ditches, and it may be used anywhere in pans or in saturated cloths, stretched on frames, drawn over the field. The method of using it on the irrigating ditches in Colorado is thus reported by Prof. R. L. Packard:

It consists essentially in pouring, or, better, dropping coal tar or coal oil on the running water with which the irrigating ditches are supplied. The method of supplying these ditches with oil is very simple. It is only necessary to sprinkle a few drops of coal tar on the stream, when the oils contained in the tar are diffused over the surface of the water, and coming in contact with the insects (no matter how many), cause their speedy death. The toxic power of coal oil upon the insects is very remarkable; a single drop of it floating on the water is capable of causing the death of a large number of insects. A simple and ingenious mode of keeping up a constant supply of the tar to a ditch I saw exemplified upon the farm of Mr. Arnett. A three-quart can is perforated on the side close to the bottom, a chip loosely fitting the aperture is inserted therein, and the can is then immersed (by a weight if necessary) in the ditch. Three quarts or less of tar, trickling out drop by drop from this slight vent, are sufficient to keep a great length of ditch supplied with coal oil for 36 hours. The precise extent of ditch which may thus be rendered toxic to the locusts can not, of course, be exactly stated. It is in fact quite indefinite, for the reason that the quantity of oil necessary to kill one of the insects is almost infinitesimal, and for the further reason that a single drop of oil will cover quite a large surface when dropped on water, so that taking these two facts together, it is easy to see that a very small quantity of tar or oil will serve to guard by means of ditches a large tract of territory from the ravages of the young (unwinged) locusts.

The pans that were used in Kansas and Iowa, but principally in the former State, were of very simple construction and very effectual.

A good and cheap pan is made of ordinary sheet-iron, 8 feet long, 11 inches wide at the bottom, and turned up a foot high at the back and an inch high at the front. A runner at each end, extending some distance behind, and a cord attached to each front corner, complete the pan, at a cost of about $1.50. (Pl. VIII, Fig. 2.)

We have known from 7 to 10 bushels of young locusts caught with one such pan in an afternoon. It is easily pulled by two boys, and by running several together in a row, one boy to each outer rope, and one to each contiguous pair, the best work is performed with the least labor. Longer pans, to be drawn by horses, should have transverse partitions (Pl. III, Fig. 8) to avoid spilling the liquid; also more runners. The oil may be used alone so as just to cover the bottom, or on the surface of water, and the insects strained through a wire ladle. When the insects are very small, one may economize in kerosene by lining the pan with saturated cloth, but this becomes less efficient afterward, and frames of cloth saturated with oil do not equal the pans. Where oil has been scarce, some persons have substituted concentrated lye, but when used strong enough to kill it costs about as much as the oil. The oil pans can be used only when the crops to be protected are small.

Small pans for oil, attached to an obliquing pole or handle, do excellent service in gardens.

Mr. A. A. Price, of Rutland, Humboldt County, Iowa, sends the commission the following description of a coal-oil pan to be drawn on runners, and which was used with much success in northwestern Iowa (Pl. VIII, Fig. 1):

Take a common board from 12 to 16 feet in length for the foundation or bed piece. Make a tin trough 4 inches deep, 6 inches wide, and as long as required. Divide the trough into partitions by means of strips of tin, so that each partition is a foot long, thus avoiding the spilling of oil. Back of this place a strip of tin 16 inches wide and as long as the trough. The back must be firmly secured by braces running down to the front edge of the board. Under all this place 3 wooden runners 3 feet long and shod with iron for the trough to ride on. Fill the pan half full of water, and then add a small quantity of kerosene—sufficient to cover the water. A horse may be hitched to the machine by fastening a rope to the outside runners. * * * The lightness of the machine will allow of its being used on any crops. * * *

A machine of this sort was patented by Mr. Lorenzo B. Canfield, of Syracuse, Nebr. (Patent No. 187,509, dated February 20, 1877). The following description and figures will serve to illustrate his pan more fully. Pl. VII, Fig. 1, represents a perspective view; Pl. VII, Fig. 2, a longitudinal sectional view on the line *x x* in the preceding.

This pan was sold in the West at an exorbitant price, $4 being charged for royalty. Wherever we had an opportunity we advised farmers not to use it, but to construct others such as we have already described, and every bit as good, at far less expense. The principle can not be patented, for since 1875 similar coal-oil pans, virtual outgrowths of the canvas frames originally employed for the same purpose, have been "known and used" in Colorado. This fact is sufficient in law to defeat any patent right based upon any application for a patent subsequent to such knowledge and use.

The essential features in all the contrivances are, in fact (1) A platform that runs on the ground, on runners or wheels; (2) A canopy at right angles with it; (3) A reservoir at the junction to contain the liquid.

Another pan, of which we give a sketch (Pl. VII, Fig. 3), was made by Mr. James Adams, of Abilene, Kansas. It is 10 feet long, 2 feet wide; back (*a*) 1 foot high; front (*b*) about 2 inches high at the inner edge; ends (*c*) 2 feet high. The front is made of a board 6 inches wide, leaning inward at an angle of about 45°. A cloth screen is placed on the back part, which prevents the reel from knocking the locusts back over the pan.

The whole is made of pine, and it costs $8 or $10. The pan is painted within with asphaltum paint, which renders it impervious to water or oil. The pan rests in front upon runners, to which ropes are attached for drawing, and on wheels behind which carry belts to turn the reel. The reel revolves just in front of the pan, causing the locusts to hop, and then knocking them into the pan. A brush of cloth is sometimes fastened to one arm of the reel to brush into the pan any locusts that may be on the front piece. Several of these pans were used about Abilene, and did good work.

A contrivance shown in Pl. VIII, Fig. 3, was constructed by President John A. Anderson for use on the Agricultural College farm at Manhattan, Kansas.

It was found to do very good service, killing the young locusts in considerable numbers. The oil did not evaporate so rapidly as was anticipated. One thorough saturation was sufficient for fifteen or twenty minutes, when a little more could be added. If the machine be hauled against the wind, nearly all the locusts which hop will touch the oiled canvas. They generally take several hops upon the canvas before leaving it, thus insuring a thorough saturation with the oil. After hopping from the apron they can take two or three hops upon the ground, then lose all power in their hind legs, stretching them straight out behind, and finally, in one or two minutes after being "oiled," they are dead.

Coal Tar.—This may be used with most of the contrivances just described for the use of kerosene, and while not equal to the simple kerosene pan for speed in trapping and destroying, is yet very useful, especially in the neighborhood of gasworks where the coal tar can be obtained at nominal cost. It also permits the use of the simplest kind of pan. Enough tar is spread over whatever receptacle may be used to cover well the bottom, and when this becomes sufficiently matted with the young locusts so as no longer to destroy the new comers, another coating is added, and so on until it becomes necessary to remove the whole mass, when it is shoveled from the pan and burned; or, what is far preferable, wherever there are wet ditches it may be thrown into these, when the oil contained in it, spreading over the surface of the water, destroys such locusts as may jump into or be driven into such ditches. Where the tar is scarce, as a matter of economy it will pay to melt the accumulated mass in iron vessels. By skimming off the dead locusts that rise to the surface, and thinning the residuum with a little coal oil, it may be used again.

A simple pan extensively employed, and which was known as the Robbins "hopperdozer,"* is shown in the accompanying illustration (Pl. IX, Fig. 1), the general plan being that of the ordinary road scraper. Its simplicity and durability account for its general use. It was usually drawn by hand, though several pans were frequently bound together and drawn by horses; while, in some instances, certain improvements in the way of mounting on wheels, so as to permit its being pushed from behind, were also adopted. We saw some with a wire screen or cover hinged to the back, so that the insects might be secured when the pan was not in motion; but the cover seemed superfluous. We also saw lime and kerosene mixed so as to form a mortar substituted for the coal tar.

Another device was used in Colorado last summer, but is more complicated. It consisted of a skeleton cylinder of wood framework covered with canvas, the interior of which was to be coated with coal tar. The ends were opened and fans were arranged there, so constructed as

* A word that came into very general use last year among farmers for coal-oil and coal-tar machines, and which doubtless takes its origin from doze, in reference to the toxic effect of the coal-tar on the locusts.

to throw the locust into the interior of the cylinder, where they would become entangled in the tar and be poisoned by it. The machine runs on wheels whose axle is the axis of the cylinder.

A correspondent of *The Kansas Farmer*, in the issue of June 6, 1877, describes the following contrivance:

I yesterday put together a machine which I do not propose to patent. It is constructed as follows: I had riveted together two sheets of stove-pipe iron, each 2 by 7 feet, making a surface of 4 by 7 feet. I rolled up the back side about 18 inches high, and held it to its place by nailing to it rounded inch boards. I turned up the front a trifle, and nailed to it a narrow strip of siding to stiffen the machine under the bottom, well back, so that it would balance. I fixed a three-eighths round iron for an axle, and fastened it by driving a staple over it near the ends and into the board end pieces. The wheels should be 16 inches in diameter, made of inchboards, three thicknesses nailed together, so that the grain of the wood will cross. I push my machine with a handle made of half-inch iron, a piece 12 feet long, the ends flattened, and fastened to the end board with screws, the rod bent up and made the proper shape, so as to come about to the bottom of a man's vest when operating the "dozer." I cover the surface with tar (common), which will burn and is poison to the 'hopper. The machine tilts over the axle and can be made to scrape the ground or raised to pass over grain or obstructions. The "dozer" is a perfect success, gathers the 'hoppers almost as clean as a reaper will cut grain; none get away. One week's work and 4 gallons of pitch tar will clean the worst 'hoppered 160-acre farm in Minnesota. At one priming with tar yesterday my man caught in about an hour a half bushel, estimated to make 10 bushels when grown.

(4) CATCHING OR BAGGING.—"There are innumerable mechanical contrivances for this purpose. The cheapest and most satisfactory are those intended to bag the insects. A frame 2 feet high and of varying length, according as it is to be drawn by men or horses, with a bag of sheeting tapering behind and ending in a small bag or tube, say 1 foot in diameter and 2 or 3 feet long, with a fine wire door at the end to admit the light and permit the dumping of the insects, will do admirable work. The insects gravitate toward the wire screen, and when the secondary bag is full they may be emptied into a pit dug for the purpose. Those bagging-machines will prove most serviceable when grain is too high for the kerosene pans, just described, and they will be rendered more effectual by having runners at distances of about every 2 feet, extending a foot or so in front of the mouth, so as to more thoroughly disturb the insects and prevent them from getting underneath; also by having wings of vertical teeth, so as to increase the scope with as little resistance to the wind as possible."

Two important facts should always be borne in mind in using these bagging-machines: First, that they should always be drawn, as far as possible, against the wind, if this be stirring; second, that in proportion as the insects and the grain are advanced in growth, and the former become predisposed to roost, in that proportion the machines will prove more serviceable at night.

We constructed a machine embodying the features already mentioned, and it answered the purpose very well indeed. The following account is from the *Scientific American:*

Professor Riley, of the Entomological Commission, perfected last summer a grasshopper machine, which seems to be just the thing. It is intended to do away with all extra material, like coal-oil, which in the long run is expensive, and to work at all seasons, whether the insects are just hatching or full grown. It is not patented, nor does the professor intend to patent it, unless it should be found necessary to prevent others from doing so. It was worked at Manhattan, Kansas, and gave great satisfaction, and was described in the *Industrialist*, the organ of the Kansas State Agricultural College, as follows: (See Pl. X, Fig. 1.)

"The mechanical department has constructed a new locust exterminator for Professor Riley. The machine operates upon the bagging principle. It is, briefly, a large canvas bag stretched upon a light but strong frame, and placed upon runners, which extend with curved tips a little in front of the mouth. The canvas is stretched upon the inside of the frame, thus making the bag smooth and even within. This bag has a mouth (A) 10 feet long and 2 feet high, and converges backward to a small box or frame, 1 foot square, with a slide cut-off (D). This box forms the mouth to a secondary bag (B), 2½ feet long and 1 foot in diameter, which ends in a second frame having two short runners below it. There is a sliding door (E) of wire gauze in the end frame, and the secondary bag is strengthened by a couple of strips of leather connecting the two small frames. The machine is made to "take more land" by means of two right-angled triangular wings (C) about 6 feet long, that hinge to the upright ends of the large frame in such manner that the rectangle joins the upper corner of the frame. From the lower side of this wing are suspended a number of teeth, or beaters, which, swinging loosely, drive the locusts inward. The machine is handled by means of two ropes hitched to the outer runners or to the outer and lower side of the mouth of the frame.

"On smooth ground the machine can be easily hauled by two men, but where the grass is tall and thick it pulls harder. The locusts, on hopping into the machine, soon reach the small back portion, enter the small bag, and are attracted to the rear end by the light which enters by the gauze door. When a sufficient number are thus captured the machine is stopped, the cut-off is slid down in front of the secondary bag, a hole is dug behind the machine, the bag tipped into it, and the insects buried. A strip of leather closes the slit through which the cut-off slips, and the main bag is made of dark cloth, while the secondary bag is white, so as by contrast to attract more thoroughly the locusts.

"The advantages of this machine are that it requires no additional expense to run it, as for oil, tar, etc. It will catch the winged locust as well as the young, if operated on cool mornings and evenings, and is adapted to almost all conditions of growing grain. The machine can be made for about $10, and perhaps less."

In practice we found it best to draw the machine by hitching to the runners, and to brace the wings at desired angles, according to the strength of the wind, by means of two iron rods, as in the illustration.

A net which has done good service, made by Maj. J. G. Thompson, of Garden City, Minnesota, is as follows:

Two pieces of common batten about 16 feet long were used as framework for the mouth of the net, one for the bottom and one for the top. From the end of the bottom piece a wooden shoe of the same material ran back about 6 feet to steady the trap, and serve as a runner. To the rear end of this shoe a similar piece was fastened by a hinge, and ran forward and was fastened to the top piece of the frame, so that the mouth of the trap would open and shut like a jaw. To hold the mouth open, two short, upright posts were fastened to the top piece by a hinge, and rested upright upon the bed-piece. The net itself was made of cotton cloth for the bottom, and the top was made of mosquito-netting. The mouth of the net extended 16 feet from one side of the trap to the other, and the net ran back about 6 feet to a point with a hole

at the end to let out the insects collected. A boy 10 years old can draw one end of this net, and by the use of it, Major Thompson saved one piece of wheat.

Mr. J. C. Elliot, of Sheldon, Iowa, thus describes a machine of his own devising that was much liked in his section:

Take a strip of pine lumber 1 inch thick, 2 inches wide, and 10 or 12 feet long; about 18 inches from each end mortise in a strip about 2 feet long of the same material as your main piece; run a strong wire from one end of the main piece over the ends of the two upright pieces and fasten to the opposite ends of the main strip, forming the framework to the mouth of your dozer. The wire should be permanently fastened to the top ends of the upright pieces to form a brace to keep them always in place. Place the long strip of lumber on the ground so that the standards stand perpendicular; take two widths of strong cotton cloth the length of your main strip sew them together so you will have double width, tack one side of the cloth to the long wood strip; this forms the bottom. Take of mosquito-bar enough to form a top to the net, fastening one side to the wire running over the top of the standards; put in such gores of cotton cloth at the ends as you may need to form a complete sack of the cotton cloth and mosquito-bar. A good plan to facilitate taking out the 'hoppers when caught is to let the back part of the net run to a point in the center, and leave a small opening, which can be fastened with a string while at work, and unloosened to empty out the 'hoppers. The object of the mosquito-bar is to allow the wind to pass through and keep the 'hoppers in the net.

A very successful method of catching pupæ was used by Mr. Lowe and Mr. Hall, farmers, in McLeod County, Minnesota. It is simply equivalent to a wagon-body with one side removed, to be drawn over the grain after dark. The locusts roosting on the grain fall into it, simply lie there and become entangled in a mass, and may be easily shoveled into a hole. Mr. Hall thinks he caught 800 bushels in the latter part of June; Mr. Lowe, 400.

While in Iowa we inspected one of the following machines, which was not in working order, however, at the time, nor was it much used, even in the locality where invented. It is patented by Mr. George S. Wilson, of Malvern, and Mr. John Rhode, of Tabor, Iowa (patent No. 192,553, dated June 26, 1877), and is described below. (Pl. XI, Fig. 1.)

a a represents two driving-wheels, upon which the machine is propelled about by a person or persons pushing from behind on the handle *c*. The frame consists, preferably, at each end of the two curved timbers *d*, as shown, between which is clamped a curved sheet-metal plate, *e*, which forms the floor of the machine. Secured to the inside edge of the top timber, at each end, is a curved plate, *g*, which forms a flange along each end of the machine, in order to prevent the insects from being swept or jumping from the floor.

To the rear edge of the floor is secured a box or receptacle, *i*, as long as the floor is wide, into which the insects are swept whole by the reel *h*. The cover of this box does not quite reach to the forward edge, thus leaving the space 1, through which the insects fall into the box. The upper end of the lid is turned backward a considerable distance, so as to form the flange 2, thereby preventing the insects from being swept back past the floor and opening 1 upon the ground behind.

Extending across the front edge of the machine is a board or bar, *n*, sharp at its front edge, and the ends of which project beyond each side of the frame, and serve as a support for one of the three braces or standards 3, upon the tops of which the reel is journaled, and operated by the belt or chain 8 over the pulleys 9. The axles 5, upon which the wheels *a* are placed, have their inner ends made U-shaped, so as to

straddle over the edges of the timbers *d*, to which they are secured by set-screws. By thus forming these spindles a heavy axle is dispensed with, and the wheels can be adjusted back and forth, so as to regulate the distance the edge of the floor shall travel from the ground.

The sweeps of the reel may consist either of plain strips of wood, or the strips may have sheets of rubber or any other suitable material clamped in between or secured to them, as shown.

Mr. Samuel Godard, of Marysville, Missouri, invented a machine for catching locusts (patent No. 191421, dated May 29, 1877), of which we give the accompanying illustrations.

Pl. XI, Fig. 3, is a plan view of the invention; Pl. XI, Fig. 4, is a vertical section of the same, and Pl. XI, Fig. 5, represents an end view of the revolving frame.

A machine somewhat like the above was invented by Mr. Finley E. Benson, of Walnut, Iowa (patent No. 184223, dated November 14, 1876). Pl. XI, Fig. 6, represents a plan view of the machine, and Pl. XI, Fig. 7, a vertical section of the same.

The machine invented by Mr. Dexter H. Hutchins, of Algona, Iowa (patent No. 187012, dated February 6, 1877), differs from all the others in having attached a contrivance for killing the insects by means of sulphur fumes. Pl. XII, Fig. 1, is a top view, and Pl. XII, Fig. 2, shows a sectional view.

Another contrivance was invented by Mr. Benjamin Sylvester, of St. Peter, Minnesota (patent No. 188760, dated March 27, 1877), of which drawings are herewith given.

The "Hero 'Hopper-catcher," constructed by John Carlen, Bernadotte, Nicollet County, Minnesota, is a simple bag with fan attachment, working somewhat on the same principle as the above.

Most of these patent contrivances are open to the objection of extra cost and complication without extra efficiency, and the simpler devices will always retain their deservedly greater popularity.

Mr. J. S. Belt, of the firm of Perkins & Belt, St. Paul, Minnesota, constructed a simple sheet-iron pan, intended to hold the locusts without the aid of coal-tar. The machine consists of a sheet-iron platform with a front sweep of 8 feet, the back of which is elevated 7 inches and the front 1¾ inches, in the shape of a runner. Over the platform is a contrivance that holds the locusts that hop upon the machine, and an effective cover prevents any from hopping over the grate. The implement is easily pulled by ropes, and, with a 3-foot wing on each side, it sweeps over 14 feet of field. Its capacity is 3 bushels, and it can be emptied in 10 seconds.

The following letter from Mr. Pennock Pusey, private secretary to Governor Pillsbury, expresses the opinion of those fully competent to judge of its value:

This will be handed you by Mr. J. E. Belt, who will exhibit a locust-machine, which strikes the governor and myself as the best thing yet invented. It is on the same simple principle as that of the sheet-iron and tar dozer, but dispenses wholly with

the tar, and thus saves cost and delay. It was tested yesterday by Mr. Raney, of Le Sueur County, who is probably the most practical authority in the State, and he heartily indorses it, as you will see by his letter. The inventor proposes to rush the manufacture of them extensively, and, all things considered, it seems worthy of notice.

We requested Mr. Whitman, our special assistant in Minnesota, to see the pan tried; he did so, and found it to work well, though it accomplishes nothing more than the tar-pan, and, on account of being more expensive at first cost, was not so generally used. The pan has, we believe, been patented, and can be built for $6.

Under the present head may be mentioned the method that has been and may be in future adopted, under peculiar and favorable circumstances, of driving the insects into streams and catching them, as they float down, in sacks; and, finally, the use of hand-nets, such as entomologists ordinarily use in collecting and catching winged insects. This method is strongly advocated by Gerstäcker, Körte, and other European writers, and may be employed with advantage in a small way with us where special crops are to be cleared that would be injured by other methods. A simple net, such as that herewith illustrated (Pl. XII, Fig. 4), may be cheaply constructed by any tinsmith; the only material required being a piece of stout wire, a hollow tin tube in which to solder the two ends, and a piece of cotton or linen cloth, a wooden handle of any desired length being inserted in the non-soldered end of the tube.

(5) USE OF DESTRUCTIVE AGENTS—We had a number of experiments made with different insecticide mixtures in 1876 and 1877, and the results are given in detail in the first report of the Commission. The only substance which indicated possible results of value was Paris green. Mixed with twenty to thirty parts of flour it was sprinkled on the ground, and many locusts were attracted to and destroyed by it. This mode, however, can not be compared with many of those already described. Its use against the young locusts is practically of little value, because of the excessive numbers in which they usually occur. Broadcast spraying of any crop, using, to be effective, Paris green or London purple in the proportion of 1 pound to 150 or 200 gallons of water, will be useful where spraying apparatus is at hand, but it will hardly pay to construct such an apparatus for this purpose alone, in view of the cheaper remedies just described.

THE PROTECTION OF FRUIT TREES.

The best means of protecting fruit and shade trees deserves separate consideration. Where the trunks are smooth and perpendicular they may be protected by whitewashing. The lime crumbles under the feet of the insects as they attempt to climb, and prevents their getting up. By their persistent efforts, however, they gradually wear off the lime and reach a higher point each day, so that the whitewashing must be often

repeated. Trees with short, rough trunks, or which lean, are not very well protected in this way. A strip of smooth, bright tin answers even better for the same purpose. A strip 3 or 4 inches wide brought around and tacked to a smooth tree will protect it, while on rougher trees a piece of old rope may first be tacked around the tree and the tin tacked to it, so as to leave a portion both above and below. Passages between the tin and rope, or the rope and tree can then be blocked by filling the upper area between tin and tree with earth. The tin must be high enough from the ground to prevent the 'hoppers from jumping from the latter beyond it, and the trunk below the tin, where the insects collect, should be covered with some coal tar or poisonous substances to prevent girdling. This is more especially necessary with small trees, and coal tar will answer as such preventives.

One of the cheapest and simplest modes is to encircle the tree with cotton batting, in which the insects will entangle their feet and thus be more or less obstructed. Strips of paper covered with tar; stiff paper tied on so as to slope roof-fashion; strips of glazed wall paper, and thick coatings of soft soap, have been used with varying success; but no estoppel equals the bright tin. The others require constant watching and removal, and in all cases coming under our observation some insects would get into the trees, so as to require the daily shaking of these morning and evening. This will sometimes have to be done, when the bulk of the insects have become fledged, even where tin is used, for a certain proportion of the insects will then fly into the trees. They do most damage during the night, and care should be had that the trees be unloaded of their voracious freight just before dark.

Mr. George Gibbs, of Holden, Missouri, found that the whitewash was rendered still more effectual by adding one-half pint of turpentine to the pailful.

DESTRUCTION OF THE WINGED INSECTS.

The complete destruction of the winged insects, when they swoop down upon a country in prodigious swarms, is impossible. Man is powerless before the mighty host. Special plants, or small tracts of vegetation may be saved by perseveringly driving the insects off, or keeping them off by means of smudges, as the locusts avoid smoke; or by rattling or tinkling noises constantly kept up. Long ropes perseveringly dragged over a grain field have been used to good advantage.

Of the different contrivances already described for the destruction of the unfledged locusts, those intended for bagging and catching are the most effectual against the winged individuals, great numbers of which may be caught, especially at morn and eve, and late in the autumn. At such times many may also be crushed. These winged insects are more to be dreaded in the northern than in the southern portion of the locust area, for in this last the small grains are always harvested before the advent of the pests, and Indian corn is the staple that suffers. The ex-

perience of Minnesota and Dakota farmers teaches that the injury from the winged locusts is best avoided by growing such crops as will mature early. Reports were current in 1876 in Texas that farmers near Calvert had destroyed great quantities of the winged insects by fires lighted at night. We had on several occasions witnessed swarms of locusts driven before a prairie fire, and our general experience of locust habits at night forbade belief in the reports, and we requested one of our correspondents to inquire into the matter, with the following result:

I took pains to trace up, while in Texas, the report that the *spretus* was attracted by a blaze. I found it, of course, baseless, though it had attained very respectable proportions.—(J. T. Moulton, jr.)

Moderate success has been had with smudging as a means of warding off the winged swarms. The best method is to start a fire which burns with insufficient access of air, and which is made, if possible, of materials which, while burning, will give off, besides the dense smoke due to incomplete combustion, unoxidized products of distillation which in themselves are noxious (*e. g.*, buffalo chips, straw, and coal tar, etc.). The smoke and fumes from such a fire will prevent the locusts from alighting and swerve them from their course. Mr. S. T. Kelsey succeeded in saving many of his young forest trees in Kansas, in 1874, by perseveringly smudging and smoking them. He gives his experience in the following words, in the *Kansas Farmer*, August 26, 1874:

At first we tried building fires on the ground, but it was not successful. The smoke would not go where we wanted it to. We then tried taking a bunch of hay and holding it between sticks, set fire to it, and then, passing through the field on the windward side, held it so that the smoke would strike the grasshoppers. We would soon have a cloud of 'hoppers on the wing, and, by following it up, would, in a short time, clear the field. We have thus far saved everything that was not destroyed when we commenced fighting them; and while I do not give this as an infallible remedy, not having tried it sufficiently, yet it does seem to me, from what I have seen of it, that one good, active man, who would attend right to it, could protect a 20-acre field or a large orchard. But to be successful one must attend strictly to business.

The great difficulty experienced in making the smudging successful is in the inconstancy of the winds, as a sudden change in wind direction may render much previous labor unavailing. Mr. W. D. Arnett, of Bear Creek, Colorado, who has given a good deal of attention to the practical means to be employed against locusts, has endeavored to meet the difficulty by using a portable iron bucket as a fire receptacle. A large sheet-iron bucket is fitted with a perforated tube, arranged across its bottom, open at one end to admit air, and there provided with a valve to regulate the admission of air. A perforated cover, hinged to the bucket, and a handle to carry it by, complete the arrangement. Filled with some substance which burns imperfectly, such as buffalo chips and a little coal tar, and with the cover shut, an amount of air insufficient for complete combustion is admitted through the valved tube at the bottom, and the dense smoke comes out through the holes in the cover.

The burning of old bones has been tried, but found to be no more effect-

ive than other slow combustibles. The use of smoke will be effectual in proportion as farmers combine together and produce it simultaneously over extended areas.

DIVERSIFIED AGRICULTURE.

There is nothing surer than that the destitution in western Missouri and eastern Kansas, in 1874–'75, was fully as much owing to the previous ravages of the Chinch Bug as to those of this locust. The Chinch Bug is an annual and increasing trouble; the locust only a periodical one. Now, the regions indicated are, agriculturally, the richest in those two states, and, for that matter, can scarcely be surpassed in the entire country. Consisting of high, rolling prairie, interspersed, as a rule, with an abundance of good timber, this area produces a very large amount of corn and stock. Of cultivated crops, corn is the staple, and, with a most generous soil, it has become the fashion to plant and cultivate little else, year after year, on the same ground. The corn-fields alternate more or less with pastures, and there is just enough small grain to breed and nourish the first brood of chinch-bugs which pass into the corn at harvest time and which scatter over the country by breeding and harboring in the corn-fields. Not to mention the different means to be employed in counteracting the ravages of this insect, a diversified agriculture is undoubtedly one of the most effectual. It must necessarily follow that the more extensively any given crop is cultivated to the exclusion of other crops the more will the peculiar insects which depredate upon it become unduly and injuriously abundant. The chinch-bug is confined in its depredations to the grasses and cereals. Alternate your timothy, wheat, barley, corn, etc., upon which it flourishes, with any of the numerous crops on which it can not flourish, and you very materially affect its power for harm. A crop of corn or wheat grown on a piece of land entirely free from chinch-bugs will not suffer to the same extent as a crop grown on land where the insects have been breeding and harboring. This fact is becoming partially recognized, and already hemp, flax, and castor-beans are to some extent cultivated in the States mentioned. But there are many other valuable roots and forage plants that may yet be introduced and grown as field crops.

Governor Pillsbury, of Minnesota, has a few pertinent remarks on this subject in one of his annual messages. He says:

In my former messages I took occasion to urge upon farmers a greater diversification of their crops. The present tendency, I fear, is toward an aggravation rather than a correction of the evil referred to. Stimulated by recent heavy crops, land hunters have a passion for immense tracts and great wheat-farms. While the cultivation of our idle lands is always desirable, this pursuit of a single branch of farming is to be lamented. And I fear that the expectations of great profits of many inexperienced persons who are drawn into the movement by excitement is doomed to disappointment. A wiser course is to look to many sources of profit rather than to one. There is no better country than ours for the raising of stock. Our wool, beef, butter, and cheese are unsurpassed. With the production of these, wheat-growing alternates

admirably to the advantage of all the products. The continuous cultivation of a single crop must eventually exhaust the soil of the constituents for its profitable growth, while it is well known that the finest wheat crops were raised the past year on worn-out and abandoned grain-fields which had been resuscitated by a couple of years' rest in grass. It seems almost culpable to import corn, hogs, beans, and other products which can be grown here to perfection.

What Governor Pillsbury says of Minnesota is equally true of a very large portion of the country subject to locust injury. The advantage of growing more stock is especially obvious in some sections, not only as a means of best utilizing the surplus corn, but to avoid sweeping disaster; for when the locusts are so thick as to entirely sweep off cultivated crops, the wild prairie-grass is seldom so badly affected that it will not support stock.

LEGISLATION.

Too much stress can not be laid on the advantage of coöperation and concert of action, and legislation both to induce and oblige action is important. In every community there are those who persist in doing nothing to prevent locust injury. These indifferents frequently bring ruin not only upon themselves but upon more persevering neighbors, and any law will prove beneficial that will oblige every able-bodied man to work one or more days, either in the fall in destroying the eggs, or in the spring in killing the young insects, whenever the township trustees, at the request of a given number of citizens of the township, may call them to such work under special provisions similar to those of existing road laws.

In reference to bounty laws, the experience of Minnesota, where they were in force in some counties in 1875, is valuable, and the State commissioners did not hesitate to recommend the system after the county trials, imperfect as they were and commenced as they were, in most cases, too late in the season. It was clearly shown that in one township $30,000 worth of crops was saved by an expenditure of $6,000. Nicollet County paid $25,053 for 25,053 bushels of locusts, but the price paid by other counties was higher; in fact, much too high. In 1877 the bounty system was less effective, and indeed proved more or less a failure. "As a means of defense," writes Mr. Whitman, "it would have proved useless in some cases and needless in others; as a matter of relief or reimbursement for injury it would have gone in a large measure to help those who are already repaid by an abundant harvest."

Governor Pillsbury, in his annual message for 1877, speaks of the Minnesota bounty law, published further on, in the following rather severe terms:

These acts were approved by me with much reluctance, and not until I had strenuously but unavailingly endeavored to influence a correction in the act first named of what I deemed ill-advised provisions of a serious character. Prior to any movement for the practical operation of these laws, I received numerous statements from authoritative sources in all quarters of the infested regions, remonstrating against

the appointment of measurers, as contemplated, on the ground that owing to the incalculable numbers of the insects the provision requiring the counties to pay all bounties in excess of the proposed State appropriation of $100,000 would virtually bankrupt the afflicted counties. I therefore deemed it proper to defer action for further knowledge and consideration. Finding upon calculation that an equal distribution of the available fund would afford to each inhabitant of the infested localities an average of but forty cents, a sum too trifling in itself to induce additional efforts for the extermination of the pests, I became convinced that the enforcement of the bounty law would entail upon counties already impoverished by insect ravages a burden of debt which would prove more disastrous than the scourge it was intended to avert. I therefore, against the wishes of a few localities, but in compliance with a vast preponderance of petitions from the people directly interested, declined to make the appointments requisite for the practical operation of the law. The decision was justified by the result, for, in the absence of that concerted defense against the insects by ditches and other protective means dictated by experience, all efforts induced by the proposed State and county expenditures combined would certainly have been unavailing, especially where the destructive swarms were most dense and where protection was most needed from their ravages. The sum thus saved to the State remains intact, or rather the contemplated loan was not effected, the law in express terms specifying the exclusive object for which it was to be effected.

A good law, once enacted and on the statute book, may not be called into operation for many years, but would beyond all doubt serve an admirable purpose in the event of a locust invasion. The following are what we conceive should be the essential features of an efficient bounty law: (1) *The bounty should be paid out of the State treasury; or it should be graded and borne equally, one-third by the local townships, one-third by the county, and one-third by the State.* (2) *The bounty should be immediately available to those earning it.* (3) *The act should, so far as possible, tend to the destruction of the eggs.* (4) *After the eggs, the destruction of the newly-hatched locusts should be encouraged by the act.* A bushel of the newly hatched insects will contain thirty or more times as many individuals as will a bushel of the pupæ, and, moreover, their destruction prevents the subsequent injury. It would be folly to pay 60 cents a bushel for them later in the season when they are nearly full-grown and have done most of the harm they are capable of doing. The price, therefore, should vary with the season; and while, in latitude 39°, 75 cents or $1 should be offered in March, the price should diminish to 50 cents in April, 25 cents in May, and 10 cents in June. As the dates of hatching vary with the latitude, so the law should vary in the matter of dates, according to the requirements of each particular State. In addition to the foregoing requirements of such an act, every precaution should be taken to prevent fraud and dishonesty in obtaining the money.

The laws obliging proper labor will prove more beneficial to a community than the bounty laws, and the labor is best performed, first in destroying the eggs in the fall, and next in destroying the young insects after the bulk of them have hatched out in the spring.

In the more thinly settled parts of the country laws may be more or less ineffectual, so far as the general destruction of the insects is con-

cerned, though they will even there be one of the best means of relieving destitution; but in more thickly settled portions they will accomplish both results.

BRAN-ARSENIC MASH.

In 1885, Mr. Coquillett experimented with a mash composed of bran and arsenic on the devastating locust in the San Joaquin Valley, California, which was so successful that we quote his account in full.

A remedy that has been very successful in destroying locusts consists of a certain proportion of bran, arsenic, sugar, and water. These have been used in different proportions, but the one that appears to give the best results consists of one part by weight of arsenic, one of sugar, and six of bran, to which is added a sufficient quantity of water to make a wet mash.

This preparation is usually prepared in washtubs or half-barrels. One of these is filled about three-fourths full of dry bran, and to this is added about 5 pounds of arsenic, which is thoroughly stirred through the bran with a spade or shovel. Five pounds of sugar is next thrown into a pail, which is then filled with water and the sugar stirred until it is dissolved, when this sugar water is added to the bran and arsenic and the three well stirred, more water is added and the stirring continued until every portion of the mash becomes thoroughly saturated.

About a teaspoonful of this mash is placed at the root of each tree, shrub, or plant infested with locusts, dropping it in the shade when this can be done. In the case of low shrubs or plants nothing more need be done, as the locusts will find their way to the poison, but when large trees are treated the locusts should be jarred out of them, or be driven out with long poles.

I have known locusts to be killed by eating some of this mash that had been put out over a week previously. The poison works very slowly, and when put out early in the morning will show but little effect upon the locusts until quite late in the day. A Devastating Locust that I saw eating the mash at 9 o'clock in the forenoon was still alive at 6 in the evening, but was dead when next examined early the next morning.

Allowing a teaspoonful of this mash to each grape vine in the vineyard—the vines being 7 or 8 feet apart—this will require about 10 pounds of the dry bran (and arsenic and sugar in proportion) to each acre. The cost of the material will vary, but should not exceed 50 cents for each acre of grapevines, including cost of labor for mixing and applying it. For orchards the cost will be much less than this.

The addition of sugar to this mash is merely for the purpose of causing the arsenic to adhere to the particles of bran, and not for the purpose of increasing its attractiveness, since bran is more attractive to the locusts than sugar. This I have demonstrated to my own satisfaction. A quantity of sugar was placed upon the ground contiguous to an equal quantity of bran mash; when a locust came to the sugar he would eat a little of it, move on a short distance and again take a few bites of the sugar, and continue in this manner until he reached the mash, when he would settle down, eat his fill, and then move off. The locusts which came to the mash before reaching the sugar would, almost without exception, eat their fill of the mash and then walk away, but occasionally one would leave the mash and take a few bites of the sugar, only to return to the mash again. None of them eat their fill of the sugar, but always manifested an evident preference for the mash.

This mash was used upon about 300 acres of orchard and vineyard on the Buhach plantation, and about 2 weeks later scarcely a living locust was to be seen where they could have been counted by the hundred or even thousands before the poison had been applied, the ground in many places being literally covered with the dead bodies of the slain.

Several other parties also used this poisonous mash, and so far as I was able to learn, it gave entire satisfaction in every instance.

By exercising only ordinary precautions there need be no fear of endangering the lives of either man or any of the domestic animals in using this poisonous preparation. It should be mixed in a close room to prevent the arsenic from being blown about by the wind. There is no need of touching the arsenic or the mixture with the hands, as the mixing and distributing is accomplished by means of spades, shovels, wooden paddles, etc.

Of course this mixture should not be put out in places where poultry or any of the domestic animals can gain access to it. Upon the Buhach plantation were four greyhounds and several cats that were allowed to roam about the plantation where this mixture had been put out for the locusts; still, at the time that I left the plantation—about 4 weeks after the poisonous mixture had been put out—not one of them had been killed either by eating of the mixture itself or of the locusts that had been poisoned by it.

There were also several barnyard fowls upon this plantation, but not one of them was poisoned from having eaten locusts that may have found their way to the poultry range after having eaten of the poisonous mixture. Mr. Boynton, whose farm adjoins the Buhach plantation on the west, stated to me that many of the locusts which had eaten of the poisonous mixture would fall into an irrigating ditch that flowed through his poultry yard, and many of the locusts were thus carried within the reach of his fowls; still he was not aware that any of the latter had died from the effects of having eaten of the poisoned locusts.

In fact, I did not learn of a single instance where this mixture had caused the death of any person, nor of any domestic animal, although it was used very extensively in many parts of the San Joaquin Valley. Neither were the birds killed in any considerable numbers from having eaten either of the mixture itself or of the locusts that had been poisoned by it. During the 4 weeks following the putting out of this mixture upon about 300 acres of the Buhach plantation, I found only about half a dozen dead birds that had evidently met their death through the agency of this mixture; these consisted of three or four meadow larks, a bee-bird, and a field sparrow.

Rabbits and hares, or "jack rabbits," as they are commonly called, were destroyed in large numbers by this mixture. After the greater number of locusts upon the Buhach plantation had been destroyed the work of extermination was carried into a large patch of wild sunflowers adjoining the plantation on the north, and as one of the results, at least two dozen hares paid the penalty with their lives.

The four greyhounds belonging to the plantation were among these poisoned hares almost every day; still I never saw one of them attempt to feed upon the poisoned hares; certain it is that not one of them met his death from this cause.

As the mixture is saturated with water before it is put among the plants infested with locusts, there is no danger of its being blown about by the wind; and there is also very little danger of its being deposited upon the fruit by the feet of birds and insects that may have alighted upon the mixture and afterwards flown to and alighted upon the fruit. As the mixture becomes dry its particles adhere together, forming a solid mass which could not be blown about by the wind.

I have never seen this poisonous mixture used in grain fields, but know of no reason why it would not prove very effectual in such fields. Great care should be exercised in using it in alfalfa fields, but if it were placed upon small pieces of boards it could doubtless be used with entire safety in such fields; but of course it would not be safe to pasture any animal in such fields, even after the poison had been removed.

EXPLANATION TO PLATE I.

FIG. 1.—ROCKY MOUNTAIN LOCUST: *a, a, a,* female in different positions, ovipositing; *b,* egg-pod extracted from ground, with the end broken open; *c,* a few eggs lying loose on the ground; *d, e,* show the earth partially removed, to illustrate an egg-mass already in place and one being placed; *f,* shows where such a mass has been covered up. (After Riley.)

FIG. 2.—ROCKY MOUNTAIN LOCUST: Anal characters of female, showing horny valves. (After Riley.)

FIG. 3.—ROCKY MOUNTAIN LOCUST: Enlarged end of body of female, showing the method of oviposition; *j,* the oviduct; *g,* the egg-guide, and egg issuing from horny valves. (After Riley.)

FIG. 4.—EGG OF ROCKY MOUNTAIN LOCUST: *a,* showing sculpture of outer shell; *b,* the same, very highly magnified; *c,* the inner shell just before hatching. (After Riley).

FIG. 5.—EGG-MASS OF ROCKY MOUNTAIN LOCUST: *a,* from the side, within burrow; *b,* from beneath; *c,* from above, enlarged. (After Riley.)

FIG. 6.—THE DRUM LOCUST-CRUSHER: Plan view.

FIG. 7.—THE DRUM LOCUST-CRUSHER: Vertical section.

EXPLANATION TO PLATE II.

FIG. 1.—THE SIMPSON LOCUST-CRUSHER: Perspective view.

FIG. 2.—THE SIMPSON LOCUST-CRUSHER: Sectional view.

FIG. 3.—THE SIMPSON LOCUST-CRUSHER: Sectional view, when ready to remove the insects.

FIG. 4.—THE HOOS LOCUST-CRUSHER: Top view.

FIG. 5.—THE HOOS LOCUST-CRUSHER: Vertical section.

EXPLANATION TO PLATE III.

FIG. 1.—THE HOOS LOCUST-CRUSHER: Side view.

FIG. 2.—THE HANSBERRY LOCUST-CRUSHER: Top view.

FIG. 3.—THE HANSBERRY LOCUST-CRUSHER: Front view.

FIG. 4.—THE HANSBERRY LOCUST-CRUSHER: Sectional view.

FIG. 5.—THE HANSBERRY LOCUST-CRUSHER: Slide attachment.

FIG. 6.—THE KENWORTHY LOCUST-MACHINE: Plan view.

FIG. 7.—THE KENWORTHY LOCUST-MACHINE: Side view.

EXPLANATION TO PLATE IV.

FIG. 1. THE PETELER LOCUST-CRUSHING MACHINE: Front view.

EXPLANATION TO PLATE V.

FIG. 1.—THE PETELER LOCUST-CRUSHING MACHINE: Side view.

FIG. 2.—THE KING SUCTION MACHINE: Front view.

EXPLANATION TO PLATE VI.

FIG. 1.—THE KING SUCTION MACHINE: Side view, in operation.

EXPLANATION TO PLATE VII.

FIG. 1.—THE CANFIELD COAL-OIL PAN: Perspective view.

FIG. 2.—THE CANFIELD COAL-OIL PAN: Longitudinal view.

FIG. 3.—THE ADAMS LOCUST-PAN.

EXPLANATION TO PLATE VIII.

FIG. 1.—THE PRICE OIL-PAN.
FIG. 2.—SIMPLE COAL-OIL PAN.
FIG. 3.—THE ANDERSON COAL-OIL CONTRIVANCE.

EXPLANATION TO PLATE IX.

FIG. 1.—THE ROBBINS COAL-TAR PAN.
FIG. 2.—THE FLORY LOCUST-MACHINE: Front view, in operation.
FIG. 3.—THE FLORY LOCUST-MACHINE: Side view of frame.

EXPLANATION TO PLATE X

FIG. 1.—THE RILEY LOCUST-CATCHER.

EXPLANATION TO PLATE XI.

FIG. 1.—THE WILSON-RHODE LOCUST-CATCHER: Side view.
FIG. 2.—THE WILSON-RHODE LOCUST-CATCHER: Top view.
FIG. 3.—THE GODARD LOCUST-CATCHER: Plan view.
FIG. 4.—THE GODARD LOCUST-CATCHER: Vertical section.
FIG. 5.—THE GODARD LOCUST-CATCHER: End view of frame.
FIG. 6.—THE BENSON LOCUST-CATCHER: Plan view.
FIG. 7.—THE BENSON LOCUST-CATCHER: Vertical section.

EXPLANATION TO PLATE XII.

FIG. 1.—THE HUTCHINS LOCUST-CATCHER: Top view.
FIG. 2.—THE HUTCHINS LOCUST-CATCHER: Sectional view.
FIG. 3.—THE SYLVESTER LOCUST-CATCHER.

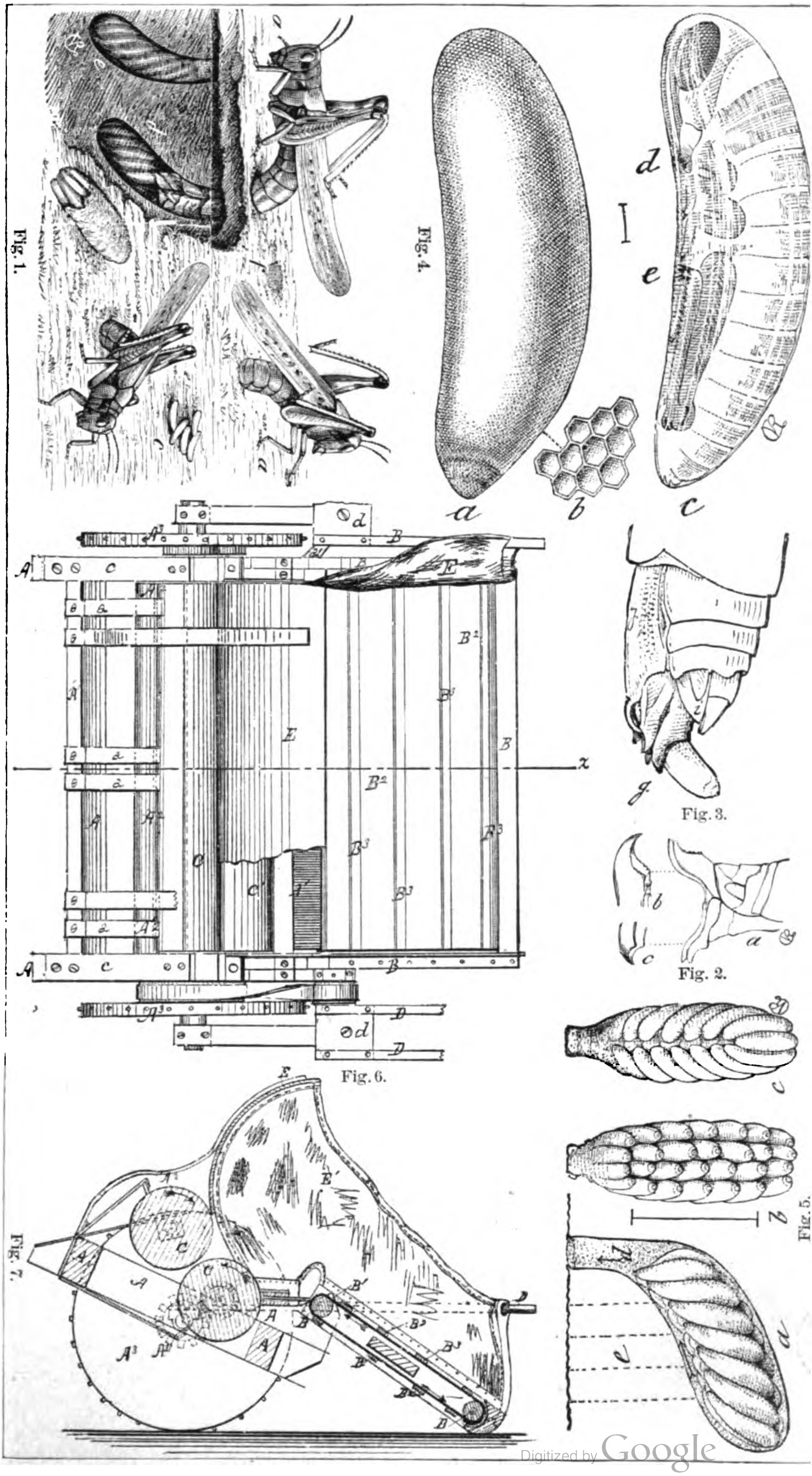
Fig. 1.
Fig. 4.
Fig. 3.
Fig. 2.
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Fig. 5.

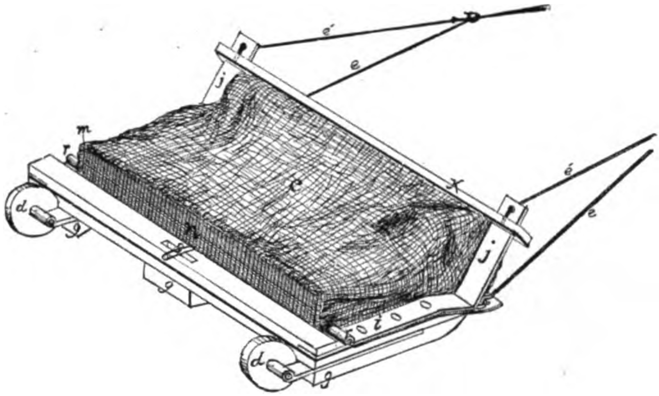


Fig. 1.

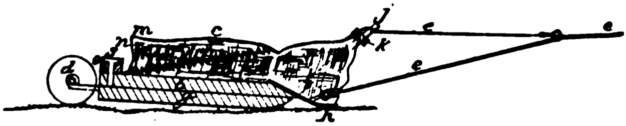
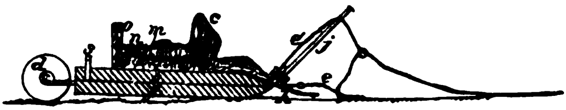


Fig. 2.



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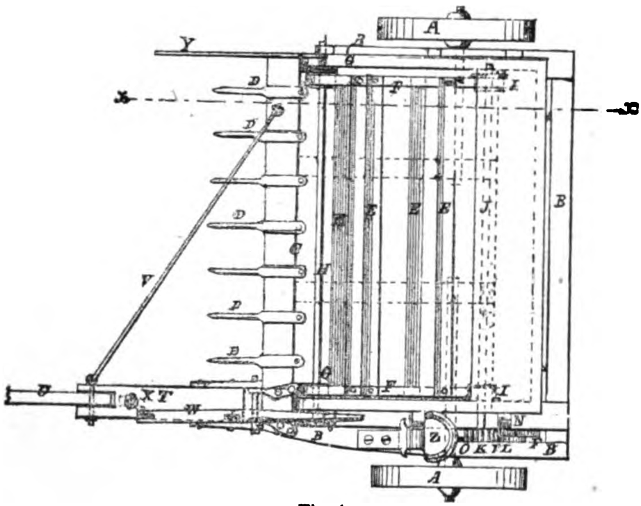


Fig. 4.

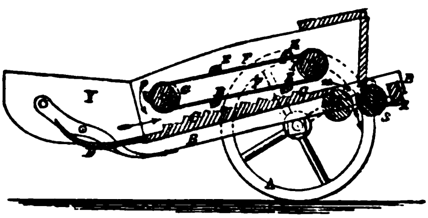


Fig. 5.

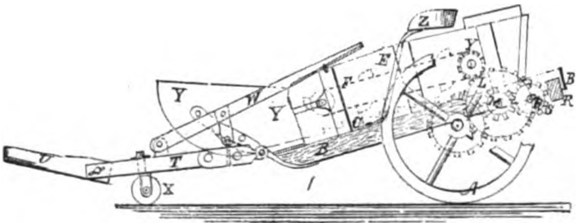


Fig. 1.

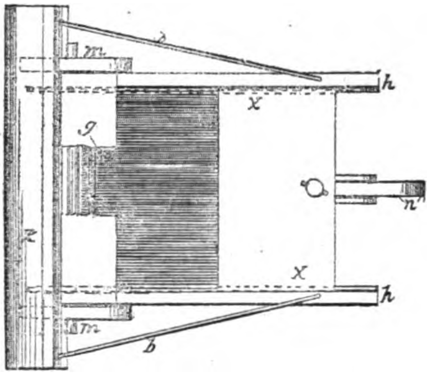
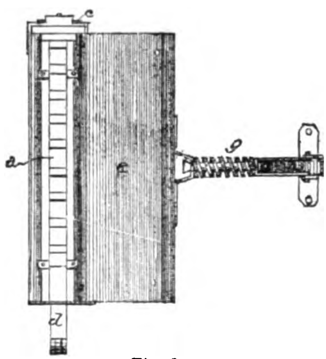


Fig. 2.



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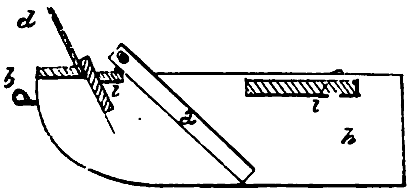

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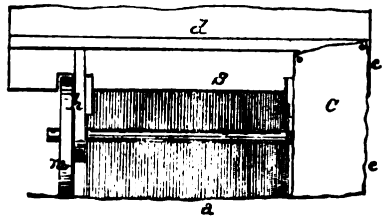

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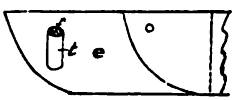

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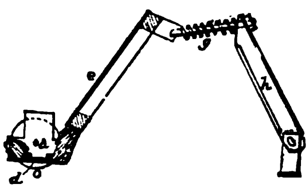

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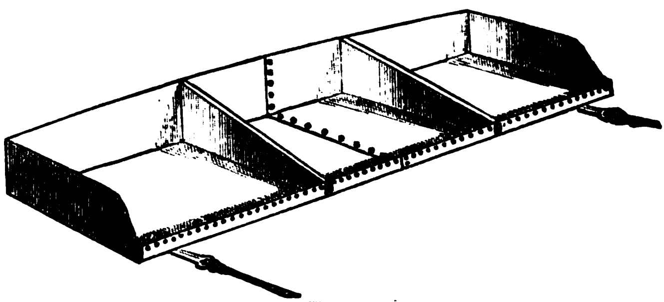

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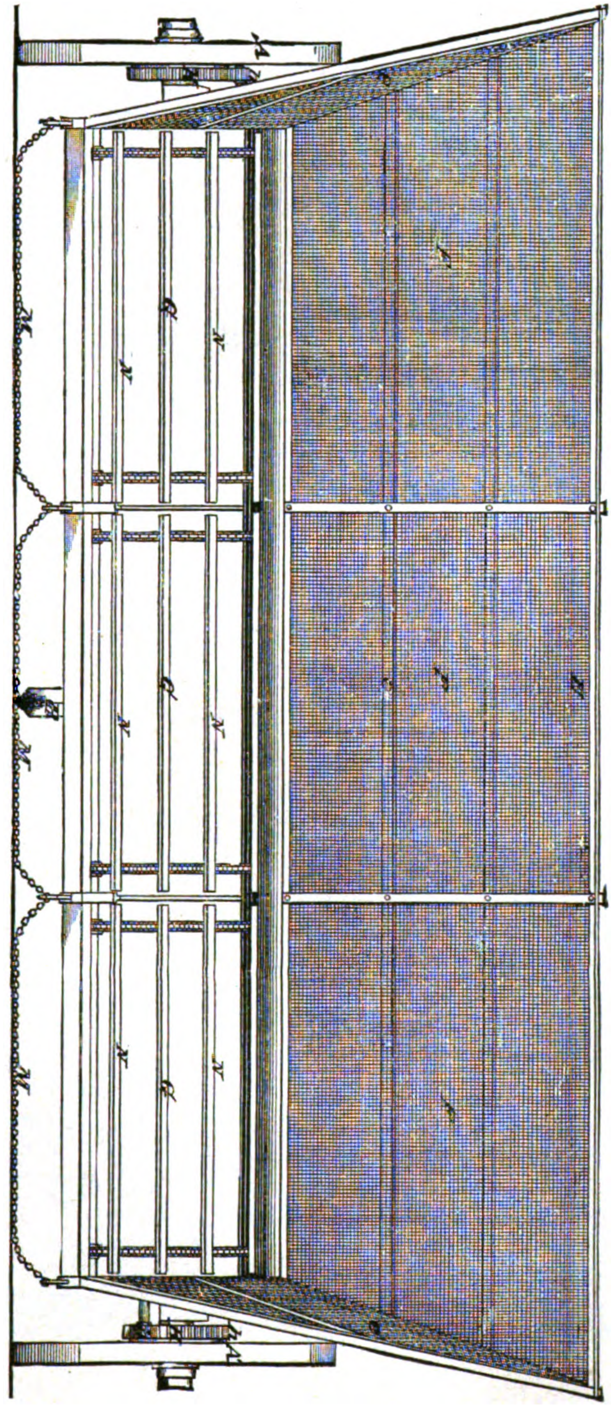

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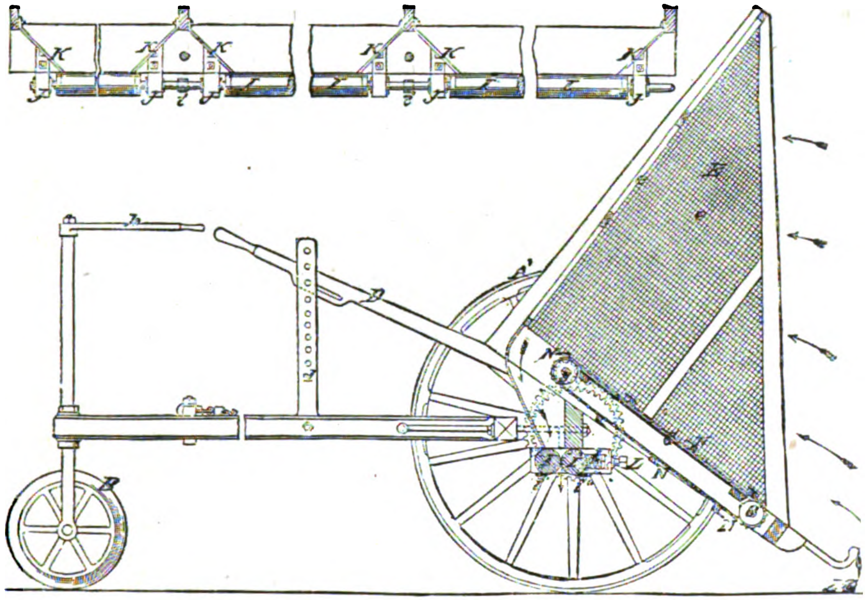

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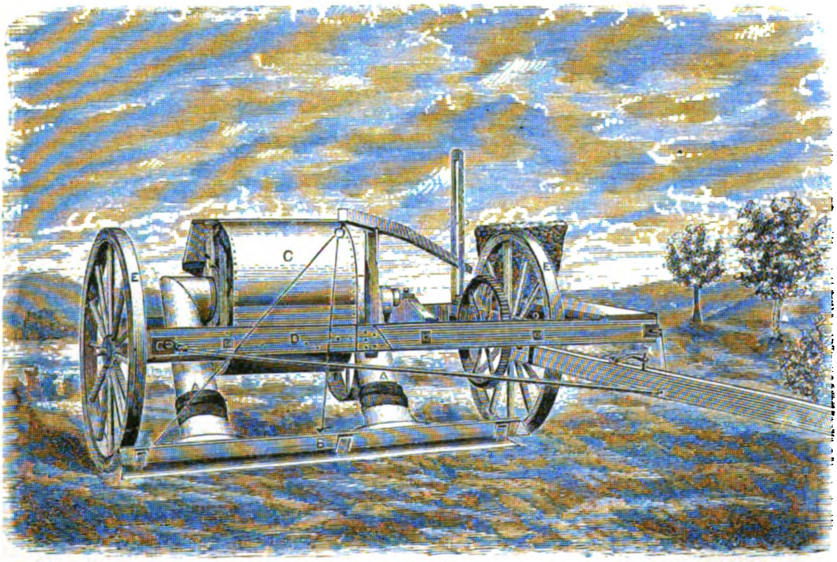

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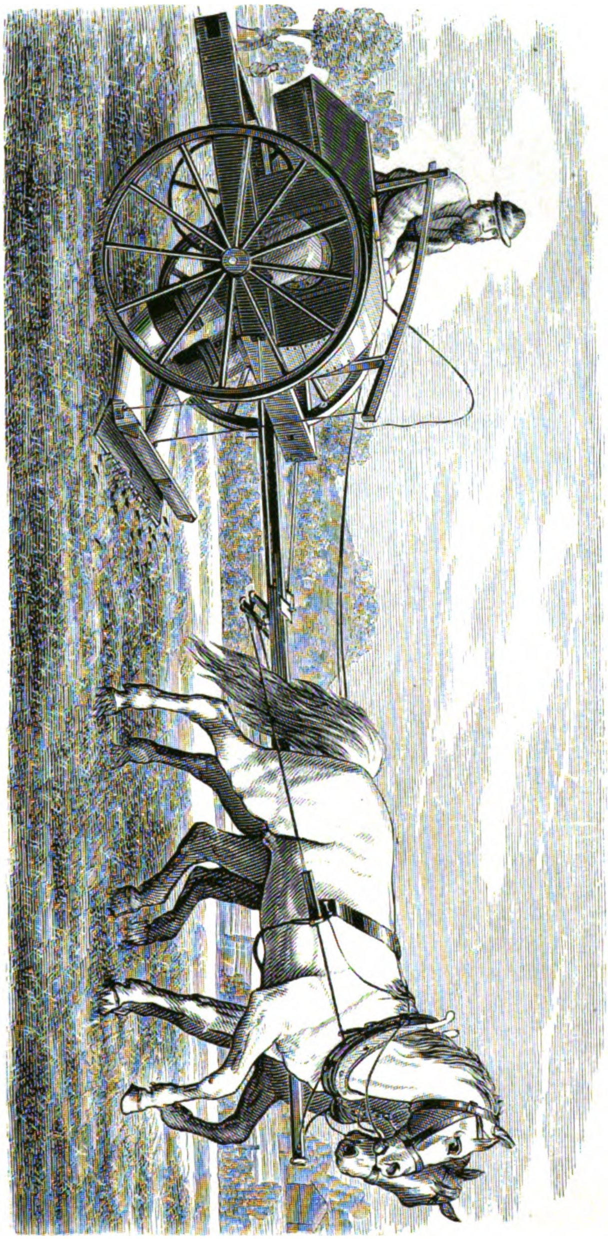

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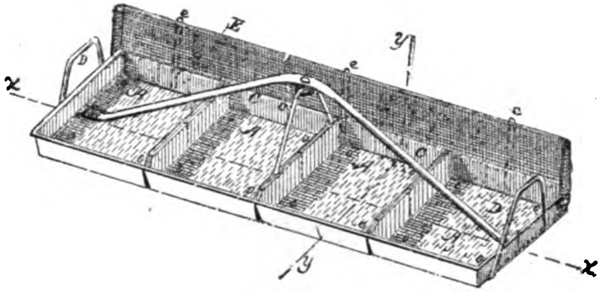

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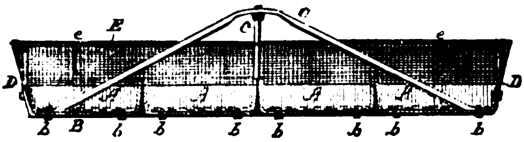

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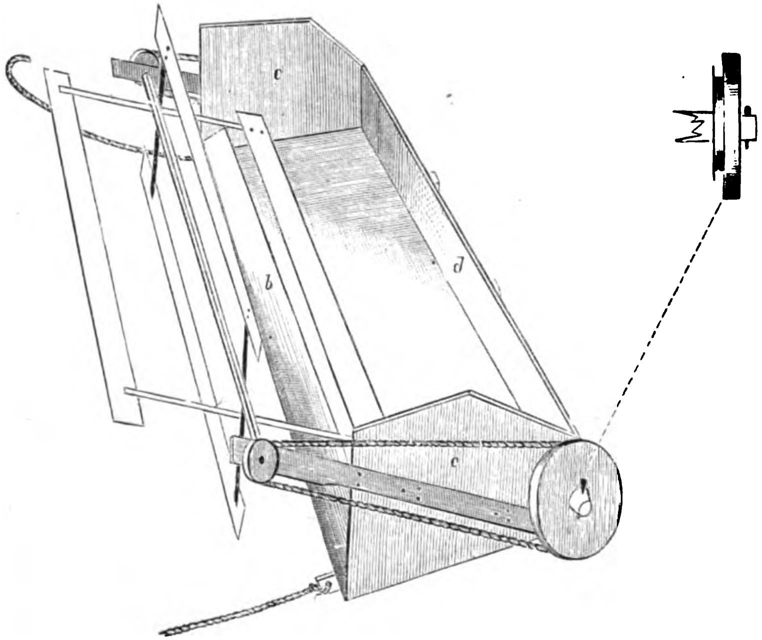

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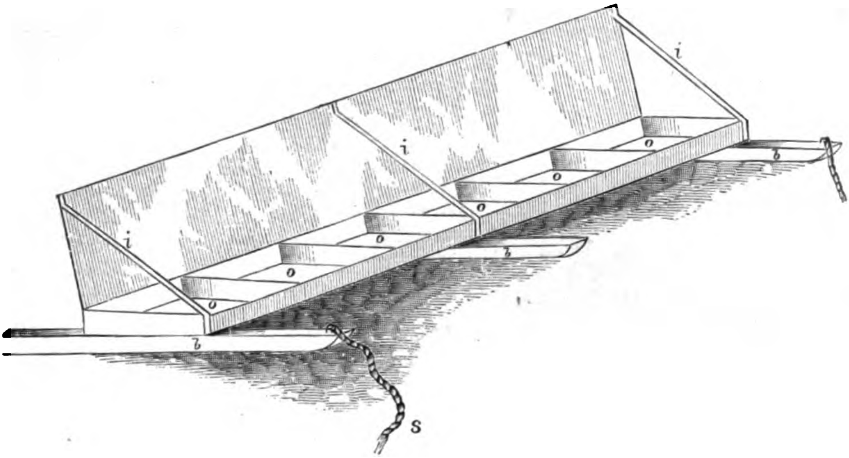

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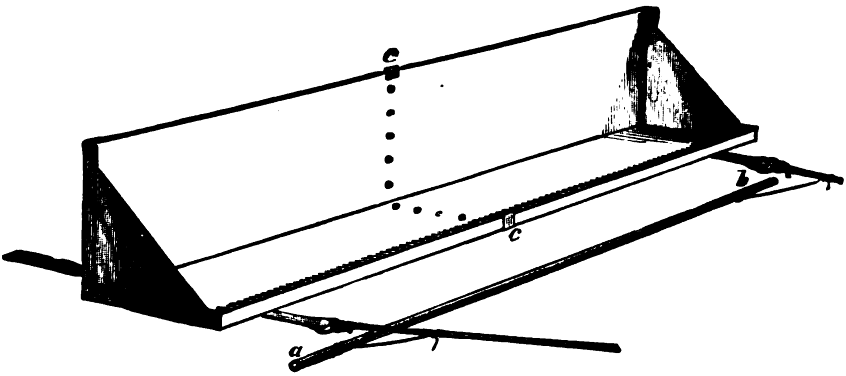

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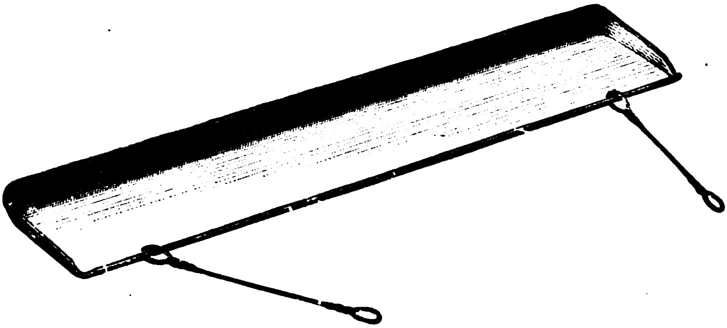

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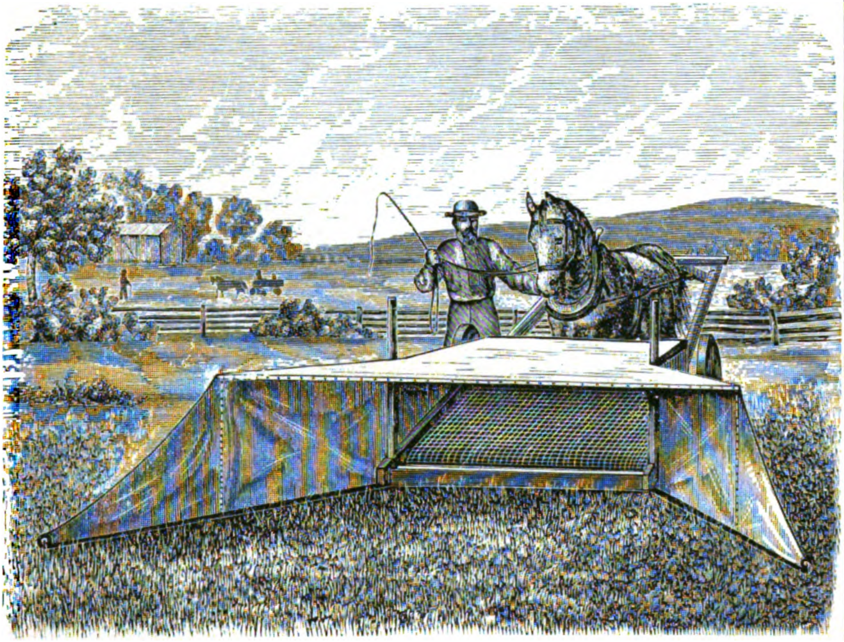

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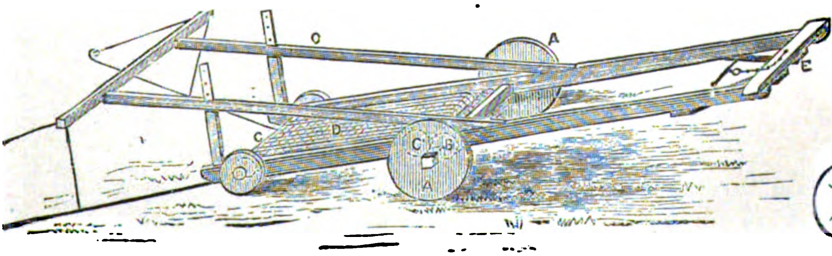

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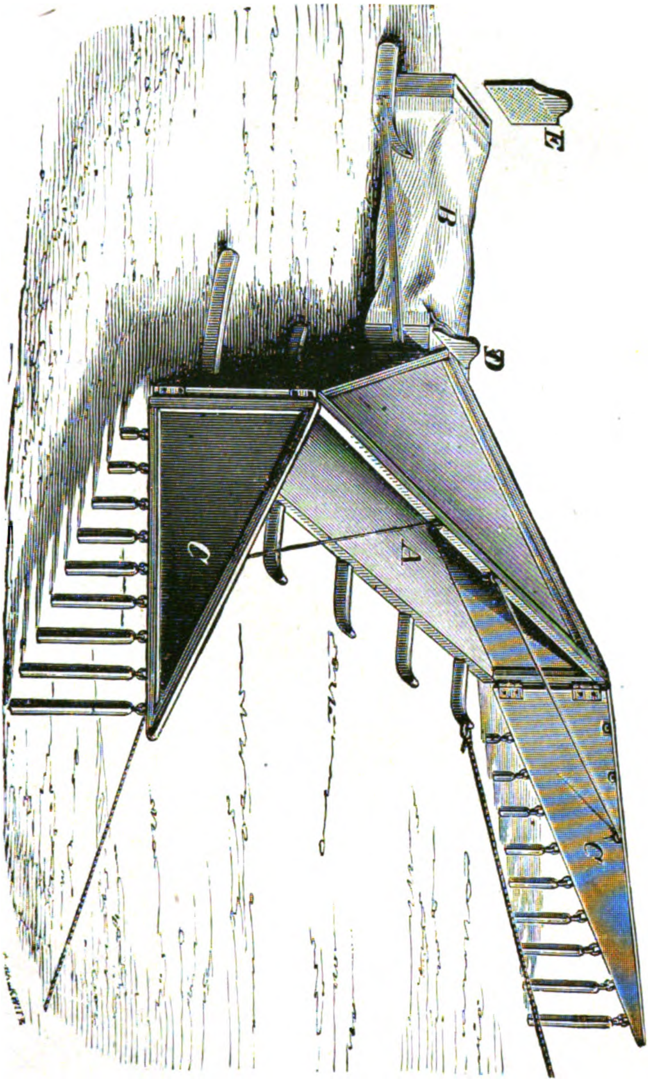

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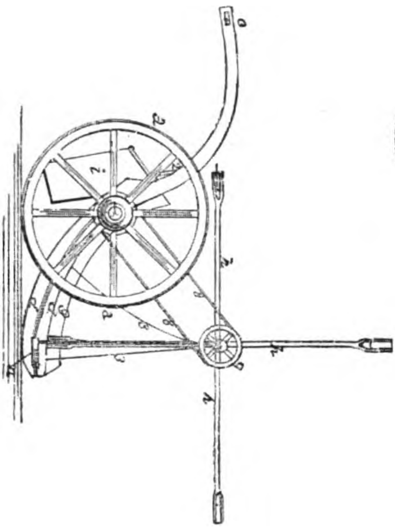

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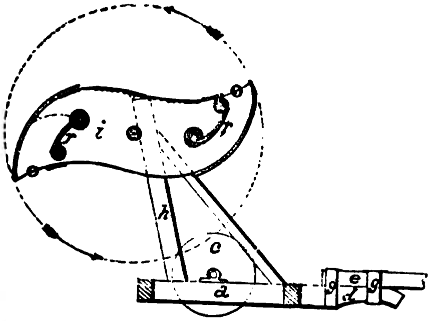

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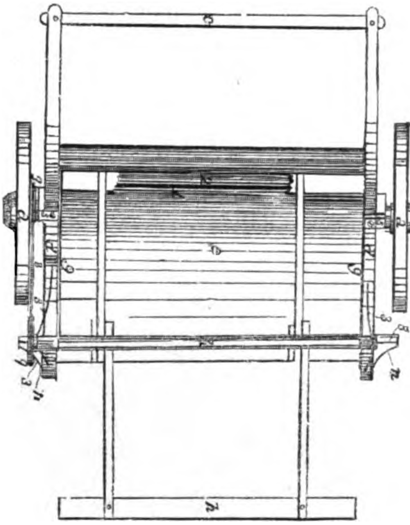

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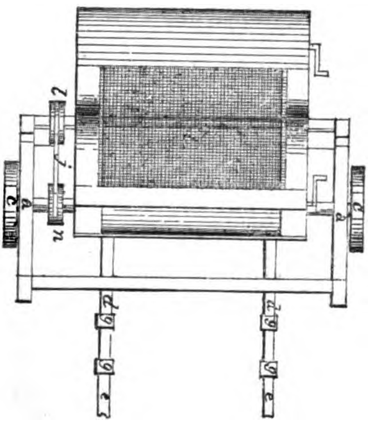

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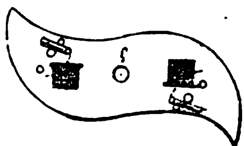

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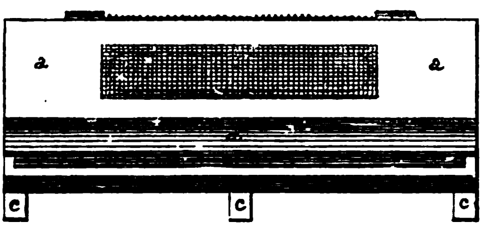

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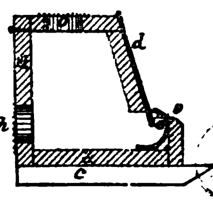

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 26.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

(PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1892.

CONTENTS.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 3, 1892.

SIR: I have the honor to submit for publication Bulletin No. 26 of this Division. It comprises the reports of the field agents of the Division for the past year (1891), a summary of which has been included in your annual report.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

REPORTS OF OBSERVATIONS AND EXPERIMENTS IN THE PRACTICAL WORK OF THE DIVISION.

INTRODUCTION.

Mr. Albert Koebele, the agent of the Division at Alameda, Cal., was sent to New Zealand and Australia early in August, and much of his time for a month or so previous to his departure was taken up with preparations for the journey. The course of experiments assigned to him was therefore interrupted, and there is no formal report from him the present season. The reports of the other agents are included in this Bulletin, including a report of the season's observations upon the Boll Worm by Mr. Mally. These reports are little more than summaries of the work performed by each of these agents. Special investigations have, from time to time, been assigned to them and upon matters of immediate importance reports have been received at different times through the year and summarized in short articles in INSECT LIFE.

Mr. Bruner's report includes only a brief account of the injurious insects which have been most prominent during the year in Nebraska. The greater portion of his time was devoted to the investigation of destructive locusts, a full account of which will be published in Bulletin No. 27.

Mr. Coquillett gives a full account of his work upon California scale-insects, and includes many new facts and the results of a number of important experiments. His report upon the work of the destructive locusts of California during 1891 will also be published in Bulletin No. 27.

Miss Mary E. Murtfeldt gives in her report her usual summary of the injurious insects of the season in Missouri and of experiments with insecticides.

Prof. Osborn, in addition to a report upon the destructive locusts of Kansas, has submitted a report upon the insects of the season in Iowa, and includes with this an account of some successful trials with a sin-

gle coal-oil pan against leaf-hoppers and young locusts, and other insects injurious to pastures.

Mr. F. M. Webster reported last year upon the development of the Hessian Fly, indicating the desirability of late sowing as a means of lessening the fall attack. He has found the present season that where this late sowing is practiced a procrastination in preparing the ground for seeding leads to the development of other injurious insects, viz, the larvæ of certain Crane-flies upon which he reports this year in full. He recommends plowing in the latter part of August or the early part of September, and refraining from seeding until later.

Prof. A. J. Cook, who was temporarily in charge of the experiments in Apiculture, reports upon a series of investigations which he carried out during the season with the help of Mr. J. H. Larrabee.

Mr. Samuel Henshaw has been engaged chiefly in work on the bibliography of economic entomology, but was requested to make some observations on the Gypsy Moth, and the report on that insect and on the work being done against it by the State of Massachusetts is also included.

C. V. R.

REPORT UPON INSECT DEPREDATIONS IN NEBRASKA FOR 1891.

By LAWRENCE BRUNER, *Special Agent.*

LETTER OF SUBMITTAL.

LINCOLN, NEBR., *October 11, 1891.*

SIR: In accordance with past custom I submit herewith a report upon the results of my labors as special field agent for Nebraska, engaged in the studies of life-histories and habits of insects related to agriculture during the past summer. In presenting this report I am pleased to be able to record a season of comparative freedom from the ravages of most of our common insect pests, but wish that it might have been even better in this respect than it has, for during years when insect depredations are comparatively light and scarcely noticeable it is safe to say that fully as much as one-tenth to one-eighth of the entire production of a country is thus destroyed.

While we have had comparative immunity from insect ravages here in Nebraska, it has not been so in some other States. Even here we have been obliged to recognize a few species as being more than ordinarily abundant and destructive. These will be mentioned briefly in the following pages.

Very respectfully yours,

LAWRENCE BRUNER.

C. V. RILEY,
U. S. Entomologist.

The present summer has been an extraordinary one for Nebraska as far as its agricultural interests are concerned. We have had abundant crops of nearly every one of our staple products, and our climatic conditions have been such as to indicate even better results for next year. But few insect enemies appeared in destructive numbers, and these few only in limited areas. Some of these are mentioned below, along with a few notes on their occurrence and habits.

MISCELLANEOUS INSECTS.

The Corn-root Worm, *Diabrotica longicornis*, appears to be alarmingly on the increase over many of the eastern counties of the State. During the past summer it has been reported from a number of new localities, and has been noted as especially numerous in some of the counties

along the Elkhorn River. Everywhere that it has been reported as uncommonly destructive investigations reveal the fact that rotation in crops is not practiced, but that corn is planted year after year upon the same grounds. This fact alone would account for its increase and spread, as has been demonstrated by repeated experiments by different entomologists as well as by farmers themselves. It had been my intention during the past summer to make special efforts to ascertain whether or not this insect had other food plants in this region, but my absence from home for the greater part of the time when this would have been under way made this investigation impossible, and it must be undertaken next year.

The Green-striped Maple Worm.—This insect continues to strip our silver maples of their leaves in the cities and towns of the State. Usually the spring brood does not appear in sufficient numbers to entirely defoliate the trees; but, as a rule, the next brood is numerous enough to do this. Thus far it has been my experience that it is next to impossible to induce the owners of property to do anything toward protecting their shade trees from the injuries of this and other insect enemies. They will do everything but the right thing, even to bandaging them with cotton (medicated) as a protection againt this and similar moths. As matters appear at present we will have an abundant crop of Maple Worms in this part of the country next year again; also a number of bared trees along the streets to advertise the ignorance of our people as to the life-history of this insect.

Lyda sp.—During the month of June specimens of the larvæ of some species of sawfly, belonging to the genus Lyda, were received from a number of correspondents residing in various portions of central Nebraska. These "slugs" were said to completely defoliate the wild plum trees of the respective localities from which the reports and specimens came. None of the mature insects were reared or received, hence I can not say to which species they belonged.

The Gooseberry Span-worm.—This insect attracted especial attention during the year. The larvæ of this moth appeared in great numbers in portions of some of the newer settled regions to the north and west of here, where in many cases they completely defoliated currant and gooseberry bushes. Over the older settled portions of the State, however, they were not reported at all. This fact is probably due to the presence of insectivorous birds and parasitic insects in greater numbers where the country has been settled for a longer time. Such is evidently the reason for having most of my inquiries come from the newer settled districts.

SUGAR BEET INSECTS.

A study of the insect enemies of the Sugar Beet has been continued throughout the spring and summer, with the results of adding several species to the list as published last year. Beyond these additions no

new facts of importance have come to light; nor do I find it necessary to change my recommendations of the use of kerosene emulsion and the arsenical sprays as remedies against the attacks of insects upon this plant.

Monoxia guttulata Lec.—This leaf-beetle has been sent to me from the Oregon Agricultural Experiment Station by Prof. F. L. Washburn, who reports it as very injurious to the Sugar Beet in the State of Oregon. He also stated that he had found three teaspoonfuls of Paris green in 4 gallons of water, in which 4 ounces of whale oil and soft soap had been dissolved, to be an effective remedy without injuring the foliage. He suggests that probably the poison would have been equally effective without the whale oil and soap.

Prof. Washburn also reports that he has taken *Hippodamia convergens* and *Diabrotica vittata* feeding on the leaves of the Sugar Beet in his State. The latter insect has also been taken here in Nebraska during the present year while feeding on leaves of both the ordinary and the Sugar Beet. *Diabrotica longicornis* has also been collected upon this plant two or three times here at Lincoln. Whether or not it feeds upon the beet, I can not say at present, since the matter has not been verified by actual observation.

Cutworms.—In the early part of the season the larvæ of several of these insects were very plentiful upon the experimental farm here at Lincoln, where they almost destroyed the entire crop of Sugar Beets growing upon two of the plats. One noticeable fact in this connection was that where there had been fall plowing and plowing again this year but few of the worms were present and consequently little injury was done to the beets growing on such portions of the field.

CABBAGE INSECTS.

Cabbage Butterflies.—These insects were not especially numerous over the State during the year, but are referred to here simply because I wish to call attention to a reported "new" remedy against them. To say the least, it is unique as well as simple, if it proves as effectual as is claimed for it. This remedy was brought to my notice about two weeks ago (September 29) while at West Point, my old home, on business connected with my work for the Division of Entomology. The remedy is simply this: The cabbage plants are sprinkled with ordinary corn meal while they are wet with dew or immediately after a rain so the meal will cling to the leaves at all points. My informant certainly had nice cabbages that were free from worms, and all he had done in the way of a preventive or remedy was to use this corn meal as above directed or explained. He claimed that in a few days after sprinkling on the meal all the worms would be found dead and turned black, clinging to the leaves of the plants. Several cabbages that had purposely been left untreated were rather full of the caterpillars of different sizes. In order to test the corn-meal remedy for myself I treated these. On

the 10th of October I received the cabbages thus treated by express just as they were when cut from the roots. The accompanying letter reads as follows:

The worms seem to become torpid at first—at least inactive, and then seem to dry up. How the meal acts on the worms I can not say. Can not say whether they eat it by itself or whether it gets mixed up with the leaves they eat, or whether the meal that gets on them, by adhering to them, acts like poison on them. The meal does not seem to do any good unless there is a heavy dew on the cabbages and it will adhere well. Perhaps they get killed by the meal getting on them while the dew is on them. But I think not.

When the cabbages were received by me the worms were dead and partly dried up, just as they had been described to me. I do not know what to think of the matter, and give the facts as they appear here.

Eleodes tricostata.—A cabbage pest in the shape of a rather active, cylindrical, grayish-brown Coleopterous larva was noted for the first time during the past spring here at Lincoln. In some of our market gardens this larva did even more injury than was committed by the various cutworms that were quite plentiful and against which we are obliged to contend every spring. This larva not only attacked cabbages, but also showed a decided inclination to feed upon various other products of the garden. It was also found to be a general feeder both upon the prairies and in the fields where it even attacked the weeds. By placing specimens of nearly full-grown larvæ into a breeding cage it was a surprise to me when I found that from them developed the common *Eleodes tricostata.* This insect appears to be greatly on the increase here in Nebraska, and especially does it seem to be increasing over the settled portions.

While speaking of this beetle, it might be well to record the fact that I have very frequently observed attached to the elytra of *tricostata* and *opaca* the eggs of some Tachina fly. In several instances as many as three or four of such eggs were observed upon the back of a single beetle. No effort has been made by me to rear these Tachinids, nor even to ascertain whether or not the eggs had hatched, and, if so, whether or not the young maggots had succeeded in entering the bodies of the beetles.

REPORT ON THE SCALE-INSECTS OF CALIFORNIA.

By D. W. Coquillett.

LETTER OF SUBMITTAL.

Los Angeles, Cal., *October 17, 1891.*

Sir: I herewith submit my annual report for the year 1891, consisting of notes on the principal kinds of scale-insects found in this State, together with the remedies employed for their destruction.

The Fluted or Cottony-cushion Scale (*Icerya purchasi* Mask.) has been kept in subjection by the Australian Ladybird (*Vedalia cardinalis* Muls.) first imported into southern California by this Division under your direction. The propagating houses erected at San Gabriel by our State Board of Horticulture at the suggestion of its president, and especially intended to preserve these Ladybirds from being destroyed by the inclement weather of the winter season, were not stocked with the ladybirds until nearly half of the winter season had passed by; from these houses a great many colonies of these useful insects were distributed to various parts of the State during the first half of the year, but none are in either of the houses at the present time and I am informed that none will be on hand for distribution before next March. Fortunately, however, Mr. A. F. Kercheval, of this city, formerly the President of our County Board of Horticulture, infested with the Iceryas a large patch of nettles growing in the hills, several miles from any cultivated orchard, and later, after the Iceryas had become very numerous upon these nettles, he introduced a number of the ladybirds among them, so that at the present time these ladybirds can be obtained from this source in sufficent numbers to meet all local demands. In accordance with your instructions I had a tent erected over an orange tree in this city for the purpose of breeding a sufficient number of Iceryas to serve as food for the Ladybirds intended to be sent to foreign countries, since I have heretofore found it quite impossible to obtain sufficient of these for this purpose from other sources.

Respectfully yours,

D. W. Coquillett.

Prof. C. V. Riley,
U. S. Entomologist.

NOTES ON SCALE INSECTS.

In this State there is no class of insects more destructive to fruit trees than those commonly known as scale insects. Other insects may occasionally strip the tree of its leaves or rob it of its fruit, but none appear over such wide areas and cause such widespread destruction to the trees themselves as do these insidious, highly destructive pests. Up to the present time but little has been written upon the habits and

early stages of these insects. A few observations of this nature are given in the Annual Report of this Department for the year 1880, furnished by the former Entomologist, who spent a few weeks in this State during the year above mentioned. The habits and natural history of the Fluted or Cottony Scale (*Icerya purchasi* Mask.) have been thoroughly studied out and a complete account has been published by Prof. Riley in the former reports and bulletins of this Department. I have nothing new to add to what has already been written and published in regard to this pest.

The following notes upon various kinds of scale-insects occurring in this State were taken by the writer during a residence of about eight years in various parts of the State, and, although of a fragmentary nature, will still throw some light upon the habits and early stages of these pests. To these notes I have added my experience with various remedies employed for the destruction of these insects.

THE RED SCALE.

(*Aspidiotus aurantii* Mask.)

This at the present time is the most injurious scale-insect that our growers of citrus fruits have to contend with. As near as I have been able to learn it was first introduced into this State in the year 1879,* upon lemon trees brought from Australia and planted in one of the orange groves of this city. Mr. Alexander Craw, who formerly had charge of a large orange and lemon grove almost adjoining the one in which these infested trees were planted, informed me that when he first saw the Red Scales upon these imported trees he feared that they would prove to be a great pest, and expressed his fears to the owner of the trees, advising him to destroy the infested trees with fire. This he promised to do, but shortly afterward was taken sick and died, and the property passed into the hands of an administrator, who claimed that he had no legal right to destroy any of the property placed in his care, and therefore the infested trees were allowed to stand and the scale spread from them to the adjoining groves until it was found impossible to eradicate them.

At about the same time that these infested trees were brought to Los Angeles others from the same locality, and like them also infested with the Red Scale, were taken to Orange and planted in one of the groves there; and from these trees almost every citrus grove in that locality became infested with these pests.

The number of broods that this species produces in one season is not definitely known, and doubtless varies with the character of the season, hot weather accelerating their development, while cool weather retards it. From observation which I have made it is quite evident that in ordinary seasons at least four generations are produced in one

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* Facts which we have not space to detail here make it tolerably certain that the Red Scale was introduced at least several years prior to this date.—C. V. R.

year. The adult female deposits eggs, but these are in such advanced stage of development that they usually hatch out within twenty-four hours after being deposited. I find by reference to my note book that on the 28th of May, at 4 o'clock in the afternoon, I found beneath an adult female of this species one recently hatched young scale-insect and two eggs, all of them being of a pale yellow color; one of these eggs hatched out a few hours after I found it and the other hatched out the day following its discovery. The young scale-insect from the last-mentioned egg had formed a thin white scale over it by 8 o'clock the next morning, the scale being regularly hemispherical in shape. This species evidently breeds during every month of the year. I have found adult males early in the month of March and as late as October. Early in March I have seen the young scale-insects crawling about, and by the latter part of July adult females may be found upon the green fruit, which usually sets in February or March. The greatest increase, however, occurs during the three months of July, August, and September.

While the Red Scale prefers citrus trees to all others, and probably could not maintain itself for a succession of years upon any other kind of tree or plant, still I have frequently found adults of this species upon the following plants growing in the immediate vicinity of infested citrus trees:

English Walnut,
Eucalyptus,
Acacia,
Pear,
Rose,
Camphor Tree,
Grape,
California Palm,
Date Palm,
Castor Bean,
Kennedya rubicunda,
Passion Flower,
Fuchsia,
Solanum douglasii,
Bidens sp.,
Solidago californica,
and various other weeds.

On one occasion I saw a young English walnut tree the bark of which was as thickly infested with Red Scales as any citrus tree could be; it was growing only a few yards from several orange trees on which these scales were extremely abundant.

Among the insect enemies of the Red Scale the Twice-stabbed Ladybird (*Chilocorus bivulnerus* Muls.) is perhaps the most common and widespread; I have repeatedly seen the larva of this ladybird tear off the upper scale and feed upon the scale-insect itself, and in some instances fully one-half of the scales on several of the oranges and lemons had been destroyed by these larvæ. For some reason, at present unknown, this ladybird never becomes sufficiently numerous to keep these scale-insects within due limits, even in restricted localities. About one year ago Mr. A. Kercheval, of this city, at that time president of the Los Angeles County Board of Horticulture, inclosed in a tent one of his orange trees quite thickly infested with the Red Scale, and then introduced into this tent a large number of these ladybirds, for the

purpose of ascertaining if they were capable of freeing this one tree of the Red Scales; but after waiting several months he found that the ladybirds had not made any appreciable headway against the Scales, the latter being quite as numerous as they were at the time the ladybirds were first confined in the tent with them.

In the early part of May, 1890, I found two of these ladybirds to the underside of whose bodies was attached a fungus growth of a yellowish color and very noticeable even to the naked eye. These specimens were submitted to Dr. Roland Thaxter, the Mycologist of the Connecticut Agricultural Experiment Station, who has made a special study of these low forms of plant life, and he ascertained that this yellowish fungus belonged to a new genus and species which he has since characterized under the name of *Hesperomyces virescens*. It is not probable that this fungus would ultimately have caused the death of the Ladybirds, since Dr. Thaxter writes as follows concerning the members of the group to which it belongs:

> The Laboulbeniaceæ constitute a small group of very peculiar and minute forms which have been placed by De Bary among the doubtful Ascomycetes. Their parasitism is an external one, which apparently results in little, if any, inconvenience to the host, each individual being fixed by a pedicellate attachment to the legs, thorax, or other portion of the affected insect. (Memoirs Boston Society Natural History, Vol. IV, p. 135.)

Another ladybird whose larva I have found feeding upon the Red Scale is an undetermined species of Scymnus, closely related to *Scymnus marginicollis* Mann., but having a distinct metallic, somewhat brassy tinge upon the wing cases. This ladybird measures less than an eighth of an inch in length; the head and thorax are of a light reddish color, the wing cases black, with a slight brassy tinge and thickly covered with rather short, light-colored hairs. Its larva has never been described so far as I am aware. It is of the same general form as the other ladybird larvæ, being broadest at the middle and somewhat tapering toward each end. The color varies from a brownish gray to olive brown, and in the younger individuals even to a blackish brown. In the middle of the back on segments from 4 to 7 is a lighter, somewhat pinkish stripe, darkest in the middle, and on the front part of segment 4 it is encroached upon by the dark ground color. There is sometimes a whitish stripe on each side of segments 2 and 3. Low down on each side of the body are two rows of black warts situated on whitish spots, each wart giving forth a cluster of several short whitish bristles. On the back are two rows of similar but much smaller warts, those on segments 4 to 7 being light-colored. The head is brownish gray, with the sides more blackish. The full-grown larva measures about one-seventh of an inch in length. When about to assume the pupa form it attaches the posterior extremity of its body to some convenient object and after a short time the skin splits open at the front end and is gradually worked backwards until it covers only

the last one or two segments of the abdomen, where it is allowed to remain. The pupa is of the usual form and of a very pale yellow color, except that the back and under side of the abdomen is tinged with orange yellow. The entire pupa is thinly covered with short light yellowish hairs. It measures about one-ninth of an inch in length. One of these larva assumed the pupa form on the 14th of July and was changed to a beetle six days later.

I have seen numerous thickly infested oranges and lemons upon each of which were from two to half a dozen of these larvæ, while the scales were so torn up as to give the infested fruit a roughened appearance very noticeable upon a slight inspection. I have also found this larva upon apple trees infested with the Woolly Aphis (*Schizoneura lanigera* Hausm.), and in such cases the larva frequently attaches to the bristles on various parts of its body portions of the woolly substance taken from the bodies of its victims.

Besides the larvæ of these two ladybirds, I have also seen the larva of the California Lace-wing (*Chrysopa californica* Coq.) feeding upon the Red Scale. Almost every fruit-grower in southern California is familiar with the appearance of these active, pale gray larvæ which have somewhat the appearance of miniature alligators, and provided with a pair of long, slender, pincer-like jaws projecting some distance in front of the head. In attacking a Red Scale this larva inserts its right mandible, or jaw, beneath the scale, then presses the tip of its other mandible against the upper side of the scale, thus bringing the scale-insect between the tips of its mandibles; in this way it extracts the juices of the scale through its right mandible which, being hollow, answers this purpose admirably. These larvæ feed upon a great variety of insects and their eggs, and even do not hesitate to attack each other, the stronger attacking and devouring or rather extracting the juices of the weaker ones, while the latter take this proceeding as a matter of course, never so much as making the least show at resistance. It is doubtless largely due to this cannibalistic propensity of theirs that these highly beneficial insects do not become more numerous and render greater service to the horticulturist by destroying the noxious insects that infest his trees and plants. Their numbers are also still further decimated by the attacks of internal parasites. From the larvæ and pupæ of this Lace-wing I have bred no less than four different kinds of these parasites, only one of which, the *Isodromus iceryæ* Howard, has as yet been described. These parasites seldom issue until after the Lace-wing larva has spun its cocoon. The parasitic larvæ spin no cocoons of their own, but assume the pupa form within the cocoons of their hosts, and, after being changed to the perfect or winged state, they gnaw irregular holes usually in one end of the cocoon, out of which they escape. I have bred two of the parasitic Isodromus from a single pupa of the Lace-wing, while from another pupa issued sixteen specimens of an undetermined species of Tetrastichus. Of the other two kinds of para-

sites referred to above, one of which is a Pteromalus and the other a Perilampus, only one specimen has thus far issued from a single pupa of the Lace-wing.

Besides the losses in their ranks occasioned by the attacks of these internal parasites, and the losses sustained through the cannibalistic habits of their fellows, the Lace-wings suffer still further from the attacks of spiders, which I have occasionally seen feeding upon the eggs of this insect as well as upon the adult Lace-wing itself. Notwithstanding the fact that the eggs of this insect are elevated on the tip of a slender pedicel, an evident provision of nature to protect them from the rapacious jaws of the Lace-wing larvæ, still many of them, as just stated, fall a prey to spiders and doubtless also to various kinds of predaceous insects, or even to the attacks of the Lace-wing larvæ themselves, as if nature were unable to cope with the scheming and cunning of her many children. With all of these drawbacks to contend with, it is not to be wondered at that these Lace-wing larvæ never become more numerous than they have at any time in the past. At the same time it is evidently not within our power to change the existing conditions to such an extent that these larvæ would become so numerous as to free our plants and trees of the noxious insects that infest them.

Besides the above-mentioned enemies of the Red Scale there are also other agencies not at present clearly understood, but which occasionally very materially lessen the numbers of these pests. A few years ago Mr. H. F. Gardner, of Orange, in the adjoining county of the same name, drew my attention to the fact that a large percentage of the Red Scales of all sizes upon his orange and lemon trees, as well as of the Black Scales (*Lecanium oleæ* Bern.) upon his olive trees were dead, although they had not been treated with any kind of insecticide. A close inspection of his trees revealed the fact that fully 80 per cent of the Red Scales upon these particular trees were dead, while upon the adjoining olive trees we found only a single colony of Black Scales still alive. This latter colony was in a sheltered situation and contained about a dozen individuals of all sizes. All of the other Black Scales upon the trees that I examined were dead and dry. In neighboring orange groves I also found several trees upon which fully 60 per cent of the Red Scales of all sizes were dead. Thinking that perhaps these might have been destroyed by some low form of fungus, I submitted specimens of them to Mr. Galloway, the Mycologist of this Department, with the request that they be examined for traces of such fungus, and under date of October 11, 1889, Miss E. A. Southworth, the Assistant Mycologist, wrote me as follows concerning them:

I have examined the scales on the lemons and find that the black ones are covered with a fungus which also spreads over the fruit to some extent. Whether or not this fungus is what kills the scales I can not say positively, but I find a little of the fungus on some of the scales that seem to be living, which would indicate that it does attack the living ones and destroys them.

In reply to an inquiry for further information upon this subject Miss Southworth wrote me as follows, under date of November 2, 1889:

I think the fungus which I found on the orange scale is a *Capnodium*, although there is an unusual absence of effused mycelium, the spores appearing to be borne mainly on upright conidiophores. It is in the conidial stage and no pycnidia or perithecia are present. It is accordingly impossible to be certain of the species, although I incline to the belief that it is *C. citri*. This species has now, however, been changed to *Meliola citri*.

I do not think I stated positively that I found the fungus on *living* scales. I found it sparingly on Red Scales, but I could not be sure they were living.

The fungus referred to as *Capnodium citri* is the same kind that causes the "black-smut" on citrus and other kinds of trees, and is supposed to draw its nourishment from the excretions of various kinds of insects that feed upon the sap of these trees. It seems very probable, therefore, that this fungus would also attack the living insects themselves, although, as Miss Southworth states, we can not say positively that such is really the case.

But, notwithstanding the great number of these scale-insects that annually fall a prey to their various insect enemies, and the thousands that perish from some cause as yet not clearly understood, still these pests manage to multiply at an astonishingly rapid rate, making it necessary for owners of infested trees to employ artificial means in order to save their trees from utter destruction.

One of the most successful remedies ever used for the destruction of the Red Scale on citrus trees is the treatment with hydrocyanic acid gas, first used by the writer in the autumn of 1886. As I gave a full account of this treatment in my annual report for the year 1890, published in Bulletin No. 23, Division of Entomology of this Department, (pp. 20 to 27) it will be needless to more than refer to it in this connection.

Among the different kinds of washes that have been used for the destruction of these scales, the one giving the best results is known as the resin wash, and is fully described in my annual report for the year 1889, published in Bulletin No. 22 of this Division (pp. 10 to 17). This wash, while it does not destroy as large a percentage of the Red Scale as the gas treatment, still is fatal to the Red Spider (*Tetranychus* sp.) and also to the eggs of the Black Scale (*Lecanium oleæ* Bern.), both of which are frequently found on the same trees as the Red Scales, and neither the Red Spider nor the eggs of the Black Scale are destroyed to any great extent by the gas. For these reasons some of our fruit-growers have adopted the method of using the gas treatment and the resin wash alternately, first spraying the infested trees with the wash in July or August, which destroys the greater portion of the Red Spiders and Black Scales, as well as a large percentage of the Red Scales. Then in November or December the trees are treated with the gas, which pretty thoroughly completes the destruction of the noxious insects infesting

them. By this method the trees may be almost entirely freed of the Red and the Black Scales, so that when the oranges and lemons are gathered the following spring they will be practically free of these pests.

THE CONVEX SCALE.

(*Aspidiotus convexus* Comst.)

This scale appears to confine itself wholly to the bark of the trees it attacks. I do not remember of a single instance where I have found it infesting the leaves. Although usually attacking the Willow, on the trunk of which it frequently occurs in immense numbers, still I have also found it upon the Lombardy Poplar, Cottonwood, Walnut, and even upon orange trees. By reference to my note book I find it stated that on the 24th of April, 1890, I found a branch of an orange tree very thickly infested with these scales. The branch at its thickest part measured about 2½ inches in diameter and was covered with these scales to a distance of about 4 feet on its basal or thickest part.

This scale-insect is quite subject to the attacks of internal parasites, although up to the present time I have known of only one species thus to attack it. This is a small Chalcid fly known as *Aphelinus fuscipennis* Howard. I have bred these parasites in June and July from scales collected in the preceding April.

If it is desired to destroy these scales this can doubtless be most readily accomplished by the use of the resin wash referred to in the preceding article.

THE OLEANDER SCALE.

(*Aspidiotus nerii* Bouché.)

This species, which appears to be pretty generally distributed all over the known world, infests a great variety of plants. I have found full-grown specimens on the following-named plants and trees:

Lilac (*Syringa vulgaris*).
Arbor Vitæ (*Thuja occidentalis*), on the cones.
Century Plant, or Aloe (*Agave americana*).
Magnolia grandiflora.
Oak (*Quercus agrifolia*).
Madrone (*Arbutus menziesii*).
Nightshade (*Solanum douglasii*).
China Tree (*Melia azedarach*).
Lemon.

I do not find by my notes that I ever found these scales on citrus trees of any kind, but I distinctly remember having found them upon green lemons still hanging upon the trees, and my impression is that I also found them upon the leaves of these trees. In the Annual Report of this Department for the year 1880, the Entomologist also records having found these scales on lemons received from various sources (p. 302).

In the above-mentioned report it is stated that the eggs of this species are very light yellow in color, but I find by reference to my note book that on the 14th of June, 1883, while examining an adult female

of this species under a compound microscope I saw her produce a living young. It would be interesting to ascertain if the same species can be both oviparous and viviparous, but my subsequent notes on this species are silent on this subject.

Although I have repeatedly inclosed specimens of this species in boxes I have never succeeded in obtaining any internal parasites from them, nor can I find any published reference to parasites having been bred from scales of this kind.

The San José Scale.

(*Aspidiotus perniciosus* Comst.)

This is by far the most destructive scale-insect with which growers of deciduous fruit trees have to contend. Its origin is uncertain, but the fact of its being so frequently found upon plants imported from Japan would seem to point to that country as the home of this pest. The name of San José Scale was first applied to this species by the late Matthew Cooke, from having first received specimens of it from the neighborhood of the city by that name in Santa Clara County. It is to be regretted that any locality should be thus stigmatized by having its name applied to a pestiferous scale-insect, and it would have been far better had the later name of Pernicious Scale, first applied to this species by the former entomologist of this Department, been adopted. However, with the late Asa Gray, I do not consider it advisable to change old names.

This scale insect never attacks citrus nor coniferous trees so far as I am aware. I have examined full-grown specimens upon the following trees:

Pear,	Prune,
Peach,	English Walnut,
Almond,	Euonymus,
Apple,	And other ornamental shrubs.

The specimens from English walnut were received from Mr. Henry H. Wheeler, a prominent fruit-grower of Pomona, who writes me that he has also found specimens of this species on almond trees.

This is the only scale-insect known to me that causes a red spot to appear upon the fruit or green bark which it infests. This discoloration is usually attributed to the saliva with which the scale-insect dilutes the sap of the infested tree or fruit, but why this should produce such a discoloration in the case of the present species but not in that of any other species is no easy matter to explain. It need not be taken for granted, however, that the saliva of all the different species is identical in its composition. That of the present species may possess some peculiar, irritating principal which does not exist in the saliva of any of the other species, and therefore the effects of the attacks would not be the same in the different species.

Young branches thickly infested by this species soon present a gnarled, knotted, and stunted appearance, and if everything is favorable to the rapid increase of these scales the tree is finally killed by them. They appear to have a discrimination in relation to their food plants that is difficult to account for. I have on more than one occasion seen Leconte pear trees growing in the midst of other varieties of pear trees which were thickly infested with these scales, and yet it was impossible to find even half a dozen specimens of these scales on the Leconte pear trees. I have also been informed that the Black Tartarian Cherry tree enjoys the same immunity from the attacks of these pests, even when completely surrounded with badly infested cherry trees.

Among insect enemies the most common and widely distributed species is, perhaps, the Twice-stabbed Ladybird referred to above in the chapter treating of the Red Scale. I have frequently seen infested pear trees upon which these ladybirds occurred in large numbers, still I never knew of an instance where even a single tree had been entirely or even very nearly freed of the scales by these ladybirds. Another ladybird which also attacks the San José Scale is the small Scymnus referred to in the chapter above mentioned, but this species, like the preceding one never occurs in sufficient numbers to entirely exterminate the scales.

Of internal parasites I have bred from these scales large numbers of small, four-winged Chalcid flies known as *Aphelinus fuscipennis* Howard, a parasite that appears to be quite a general feeder, as it has been bred from at least half a dozen different kinds of scale-insects belonging to species which are protected by a shell or scale. Although occurring in such large numbers, still this parasite is not able to keep the scales in check. It doubtless breeds throughout the year, as I have bred specimens as late as the 10th of November. Although I have never bred any other kind of internal parasite from the San José Scale, still it would appear that other kinds attack it in the northern part of the State. On the 31st of March of the present year I received from E. M. Ehrhorn, of Santa Clara County, two different kinds of Chalcid flies for naming, and in the accompanying letter occurred the statement that both of these parasites had been bred from San José Scales. These parasites proved to be the Chalcid flies, known as *Aphelinus mytilaspidis* Le B. and *Coccophagus citrinus* Craw.

It appears that certain conditions of the climate affect these scales in an injurious manner, just as is the case with several other kinds of scale-insects. A few weeks ago Mr. C. H. Richardson, of Pasadena, one of the county inspectors of fruit pests, showed me several pear trees in that locality which a year ago were very thickly infested with these scales, as was evidenced by the gnarled appearance of the branches as well as by the dry scales still adhering to the trees. After a careful examination of these scales scarcely a live one could be found. Mr. Richardson assured me that these trees had not been treated with any

kind of insecticide, and they certainly gave no evidence of such treatment. The dead scales showed no indications of having been destroyed by ladybirds nor yet by internal parasites. Wishing to ascertain if this singular mortality was general among these scales in other localities, I examined several infested pear trees in this city, but found that the fruit and new growth upon them were thickly infested with these scales, which were alive and to all appearance in a very thriving condition. It would appear, therefore, that this mortality among the San José Scales was entirely due to certain climatic influences, unless it can be shown to have been due to some low form of fungus growth.

The remedy most extensively used in this State for the destruction of the San José Scale on dormant trees is the one containing lime, salt, and sulphur, described in my annual report to Prof. Riley for the year 1890 and published in Bulletin No. 23, Division of Entomology, of this Department (pp. 30 to 34). I there gave an account of a series of experiments which I had made with the above-mentioned substances, both when used singly and also when used in various combinations, and expressed my intention of pursuing this subject still further the following winter with a view of improving upon the insecticidal properties of the wash used at that time. Accordingly, on the 10th of February, 1891, I made a number of experiments with the above-mentioned ingredients, and give herewith a brief account of the principal ones:

Experiment 260.—Sulphur, 30 pounds; lime, 43 pounds; water sufficient to make 100 gallons. The sulphur and lime were placed in the kettle together and water added; the whole was then boiled for two hours without first allowing the lime to slake; the solution did not assume an orange-yellow color as soon as in other experiments where the lime was first slaked before being boiled with the sulphur. Strained the solution and sprayed two pear trees with it at about 2:20 p. m.; sun shining; light breeze. Examined these trees March 26 and found a great many living San José Scales upon them.

Experiment 261.—Same as in the preceding experiment, except that before spraying it upon the trees I added 23 pounds of salt to the diluted solution and stirred it until the salt was dissolved, then sprayed a peach tree with it at about 2 o'clock in the afternoon. Examined this tree March 25 and found upon it many living San José Scales. Still, these were not as numerous as upon the trees treated in the preceding experiment, where no salt had been used.

Experiment 258.—Sulphur, 45 pounds; lime, 65 pounds, water sufficient to make 100 gallons. The sulphur and lime were first placed in the kettle; water was then added and the lime allowed to slake, after which more water was added and the whole then boiled for two hours. At first the solution was of a pale yellow color, but it soon became dark orange yellow, assuming this color much sooner than was the case in experiment 260, where the lime was covered with water and boiled without first being allowed to slake. The solution when properly diluted was strained and two apple trees were sprayed with it at about 2:40 p. m. I examined these trees March 26, and found quite a large number of living San José Scales upon them.

Experiment 259.—Same as in 258 except that when diluted ready for use I added 34 pounds of salt to the solution and stirred it until dissolved, then sprayed a prune tree with it at 3 o'clock in the afternoon. I examined this tree March 26 and found a few living San José Scales upon it, much less than in experiment 258, or any of the preceding ones.

In experiments 258 and 260 the bisulphide of lime (CaS_2) was formed, but this did not prove as destructive to the scale-insects sprayed with it as was the case where a certain amount of salt had been added to it. From this it would appear that the bisulphide does not of itself and alone constitute the insecticidal property of this wash; at the same time, my previous experiments prove that salt alone simply dissolved in water possesses very little value as an insecticide. Still, when these two substances are combined, the resulting solution possesses much greater insecticidal properties than does either of them when used separately.

In making the above experiments I was aided in the mechanical part of the work by Mr. C. H. Richardson, of Pasadena, who kindly placed his infested fruit trees at my disposal.

The first rain which occurred after the above experiments were made began on the morning of February 15, and continued almost incessantly for the space of two days and one night. Two days later this was followed by a long-continued rain. Since the solution was upon the trees for the space of about four days and five nights before the rain began, it would appear that it had sufficient time in which to act upon the scales before being washed off by the rain, and that its effects upon the scales would have been about the same had no rain occurred for several months after the various solutions were applied to the trees.

The wash used in experiment 261 is practically the same as the one in common use all over this State for the destruction of the San José Scale on dormant deciduous trees. Still, as stated above, it did not prove fatal to *all* of the scales sprayed with it. Even when used one-half stronger than this, as it was in experiment 259, it did not destroy all of the scales sprayed with it. These and other experiments which I made with this wash during the past winter confirm the opinion expressed in my preceding report, to the effect that this wash is not as effectual as the resin wash made one-half stronger than when used on citrus trees. I have given a full account of this resin wash of the above strength on pages 27 to 30 of Bulletin No. 23, referred to above; so it will be unnecessary to more than give the formula in this place:

Resin	pounds	30
Caustic soda (70 per cent strong)	do	9
Fish oil	pints	4½
Water, sufficient to make gallons		100

This wash can only be used upon dormant trees. Owing to the fact that in some portions of the State the winter rains interfere to a great degree with the spraying of the trees at that season of the year, frequently rendering wholly ineffectual the labor of a whole day and materially lessening the insecticidal effect of the wash used during the preceding week, it is the custom with some growers to confine their spraying operations entirely to the rainless summer season. At this season, of course, it would be impossible to use as strong a wash as

could be employed during the winter season, owing to the injury it would occasion to the foliage and blossoms or fruit. For the purpose of ascertaining how strong a wash could be used on various kinds of deciduous fruit trees during the summer season, I made, a series of experiments with resin washes of various strengths on the 4th of September of the present year. I used a wash two-fifths and also one three-fifths as strong as in the formula given above; these I sprayed upon apple, pear, peach, and prune trees a short time before the noon hour, and at a time when the sun was shining brightly, but none of the leaves on any of these trees were injured even by the strongest wash. Only the apple trees contained any fruit, but this was not injured by the wash. The stronger wash is of the same strength as that commonly used for the destruction of various kinds of scale-insects upon citrus trees in the hottest part of the summer season, and the above experiments indicate that it can also be safely used upon growing deciduous trees.

I also sprayed some of the stronger wash upon a rose bush, but the leaves on this bush were slightly injured by it; on these bushes, therefore, it would be necessary to use a somewhat weaker wash.

The Greedy Scale.

(*Aspidiotus rapax* Comst.)

This scale-insect received its name not from a voracious nature and consequent destructiveness, but rather from the fact that it infests such a great variety of different kinds of trees and plants. The following is a list of those upon which I have found full-grown specimens of this species:

Apple, Pear, Loquat, Myosporum, Birch, English Laurel, Maple, Silvertree from South Africa (*Leucadendron argenteum*), *Rhamnus croceus*, California Walnut (*Juglans californicus*), English Holly, Fuchsia, Cottonwood, Camellias from Japan, also on oranges and lemons.

The last two fruits sometimes become very thickly infested with these scales, but this seldom happens, except in the case of those allowed to remain on the trees for several months after they are ripe; in such cases I have never found one of these scales upon any other portion of the tree.

This insect was evidently imported into this State from some other country, although I can not find any reference to it in foreign countries in any work to which I have access. It is possible, however, that this is the same insect previously described by Boisduval under the name of *Kermes camelliæ*, and which has been referred to the genus *Aspidiotus* by later authors. This latter species also infests Camellias, Euonymus, and various other kinds of ornamental shrubs and trees in Europe, New Zealand, and perhaps also in other countries.

The Soft or Brown Scale.

(*Lecanium hesperidum* Linn.)

This is perhaps the most common and widely distributed of the scale-insects, being found in the four quarters of the globe, and although not infrequently occurring in large numbers, still I have never known of a single instance where a tree or plant has ever been destroyed by it. Its general effect is to weaken or stunt the infested plant and to render it black and unsightly by reason of the black fungus which always accompanies its attacks.

This scale-insect is quite a general feeder, infesting wild trees and plants as well as cultivated ones. I have found full-grown specimens on the following trees and plants:

Lombardy Poplar, Grape, Loquat, Rubber Tree (*Ficus macrophylla*), Ash, Euonymus, Maple (*Acer dasycarpum*), *Rhamnus crocea*, *Heteromeles arbutifolia*, *Rhus integrifolia*, Pepper Tree (*Schinus molle*), Willow, Apricot, Citrus trees, Fig, Locust, English Ivy, English Holly, Rose, Calla Lily, Oleander, and Pittosporum. It infests the leaves and green bark, but is very seldom found upon the fruit.

This species brings forth its young alive, although when first excluded they are still enveloped in a very thin sac, which in a short time is cast off. They remain for several days beneath the parent and then start out for themselves. The greatest number of larvæ and pseudo-ova that I ever found at one time beneath a scale of this species was twenty-four, of which number twenty-one or twenty-two were fully developed young ones. This was in the month of May, and during the same month I repeatedly found from eighteen to twenty of these larvæ beneath an adult scale.

This species is very subject to the attacks of internal parasites, of which no less than five different kinds are known to attack it in this country alone. Of this number I have bred *Encyrtus flavus* Howard, and *Coccophagus lecanii* Fitch from specimens of this scale-insect collected in this city. The *Encyrtus* attacks principally the larger scales, each of which frequently contains three or four of the parasites lying transversely to the longest diameter of the scale, and readily distinguishable by their lighter yellow color. On the other hand, the *Coccophagus* principally attacks the younger scales, only one of the parasites infesting a single scale, which it causes to swell up and assume a blackish color. I have frequently found whole colonies of these scales every member of which had been destroyed by one or the other of these parasites.

On the 11th of October, 1890, I collected several of these parasitized scales, all of which had been killed by having been subjected to the treatment with hydrocyanic-acid gas referred to in the chapter on the Red Scale, and three days later an apparently healthy specimen of *Coccophagus lecanii* issued from one of them. This parasite being in the

pupa state at the time its host was subjected to the poisonous gas, was not affected by the gas to the same degree it would have been if in the perfect or adult state, since I have repeatedly proven it to be a fact that larvæ and pupæ of insects are not affected by this gas to the same degree that the adult insects are. At the same time, when a scale is infested with one of these parasites and is sprayed with a resin wash sufficiently strong to kill the scale, this also proves fatal to the included parasite. This is one of the many advantages which the gas treatment possesses over any kind of a wash for destroying scale-insects.

Besides the gas treatment and the resin wash, both of which are referred to above in the article treating of the Red Scale, another remedy, which has the advantage of being very simple and nearly always at hand, consists of spraying the trees with a solution of common brown laundry soap—1 pound dissolved in 3 gallons of water. I have seen all of these scales on small orange trees entirely destroyed by a single application of this remedy.

The Hemispherical Scale.

(*Lecanium hemisphæricum* Targ-Tozz.)

My collection contains three different forms of Lecanium which are here commonly known under the name of *L. hemisphæricum.* The largest individuals of the largest form measure 5^{mm} long by 4 wide and 3 high; these I have found upon pear and orange trees, and also on Sycamore (*Platanus racemosus*), Wild Lilac (*Ceanothus divaricatus*) and on California Holly (*Heteromeles arbutifolia*). The largest individuals of the medium form measure only $3\frac{1}{2}^{mm}$ long by 3 wide and 2 high; these I have found only on orange trees. The third and smallest form I have found only upon the Hare's-foot Fern (*Davallia canariensis*), where they occurred in such large numbers as to kill the plant infested by them. The largest individuals measured only 3^{mm} long by 2 wide and $1\frac{1}{2}$ high. The largest form is evidently the *Lecanium hibernaculorum* of Boisduval (originally described as a Chermes), since it agrees very well with the description of this species given in *The Entomologist's Monthly Magazine*, Vol. XXII, p. 78. This description is by Dr. J. W. Douglas, who has made this group of insects his special study, and who had before him specimens identified by Dr. Signoret, the highest authority upon scale-insects. The medium form found upon orange trees is evidently the true *hemisphæricum*, while the smallest one is just as certainly the *Lecanium filicum* of Boisduval (also originally described as a Chermes). Mr. Maskell, of New Zealand, another well-known authority upon scale-insects, considers *hemisphæricum* and *filicum* as belonging to one and the same species, and is inclined to consider *hibernaculorum* as being only a larger variety of the above species; it is very doubtful, however, that he had the true *hibernaculorum* before him when making his observation, since the measurement he gives (one-ninth of an inch in di-

ameter, being less than 3^{mm}) is much too small for my specimens and those described by Dr. Douglas. The latter author considers these three froms as belonging to three distinct species. The specimens in my own collections indicate that *hibernaculorum* is undoubtedly distinct from the other two forms, being larger, destitute of distinct lateral carinæ, and the flattened margin is much narrower than in either of the other forms. I incline to the belief, with Maskell, that *hemisphæricum* and *filicum* are but forms of one species, but to settle this point definitely it would be necessary to compare the larvæ of these various forms which as yet I have not had the opportunity of doing. Neither of these three forms are at all common in this portion of the State.

The Black Scale.

(*Lecanium oleæ* Bern.)

This scale-insect is widely distributed, being found in nearly every portion of the civilized world, living in greenhouses in the colder countries and in the open air in the warmer climates. It is not so destructive to plants as some of the other species are, and I have never known of a single instance where a tree or plant has been killed by them, although they sometimes occur upon certain trees in immense numbers. The injury caused by them is seen in a general weakening of the entire tree, which, if badly infested, is rendered unsightly by reason of the black fungus which exists upon the liquid exudations of these insects.

Citrus trees are very subject to the attacks of these scales, and the fruit of trees infested by them is rendered so unattractive in appearance on account of the black fungus above referred to that its market value is much less than it otherwise would be. Among deciduous trees the Olive and Apricot appear to be more subject to the attacks of these scales than any of the other kinds. The Black Scale, however, does not appear to be very particular as to the kind of plants upon which to gain a sustenance, as will be seen by reference to the following list of plants and trees upon which I have found full-grown specimens of this scale-insect:

Citrus trees.	Lombardy Poplar.
Apricot.	Myosporum.
Almond.	*Melaleuca purpurea.*
Sycamore.	English Laurel.
Rhus integrifolia.	English Holly.
Heteromeles arbutifolia.	Beech.
Oleander.	Ash.
Baccharis viminalis.	*Acer dasycarpum.*
Ficus macrophylla.	*Rhamnus crocea.*
Habrothamnus elegans.	Pepper Tree.
Guava.	*Grevillea robusta.*
Irish Juniper.	*Ligustrum japonicum.*

Indian Cedar.	*Sonchus oleraceus.*
Cedar of Lebanon.	*Cycas revoluta.*
Euonymus.	*Artemisia californica.*
Red Pepper.	*Solanum douglasii.*
Castor Bean.	Abutilon.

Quite a large number of these plants and trees in this list are wild ones, and in several instances they were situated several miles from cultivated plants of any kind. There can be little room for doubting that in these instances the scales were carried to them by birds which had visited the infested cultivated plants, and afterwards flown to and alighted upon the wild ones.

The observations which I have made upon these scales indicate that there is but a single generation produced each year. I give herewith my notes upon this subject as I find them recorded in my note books; these notes cover a period of several years, but were mostly made in Los Angeles County.

February 4.—Found a great many empty scales of *Lecanium oleæ* on orange trees on the green twigs near the terminal ends of the branches; also found a great many young ones from 1 to 1¼ mm. long, some of which show the dorsal and two transverse carinae quite distinctly.

February 8.—Found several *Lecanium oleæ* about one-half grown on *Baccharis viminalis.*

February 10.—Found empty scales and a great many young of *Lecanium oleæ* on an Oleander.

March 11.—In an extended search for the eggs of the Black Scale today none were found.

March 30.—Found Black Scales about one-third grown on Indian Cedar and Cedar of Lebanon.

March 31.—Found several eggs of the Black Scale.

April 1.—Found a living Black Scale, beneath which were about fifty eggs, the first I have found this year; found no other eggs of this species after an extended search, the majority of the scales being not more than half grown.

April 3.—Found a Black Scale, beneath which were about a dozen eggs, but the most of the other specimens were not yet fully grown.

April 16.—Found a few eggs of the Black Scale.

May 21.—Eggs of the Black Scale just beginning to hatch.

June 2.—The Black Scales have deposited from one-third to one-half of their eggs.

June 3.—Beneath the largest *Lecanium oleæ* I could find on an orange tree were a trifle over 2,200 eggs and young larvæ.

June 22.—Received many Black Scales on Oleander from Santa Clara County; they were from one-half to fully grown, and several of the latter individuals covered eggs.

August 10.—Under some adult Black Scales all of the eggs have hatched out, while beneath others from one-sixth to one-third of the eggs are still unhatched.

September 22.—Found no eggs of the Black Scale after an extended search.

These observations were made upon scales living in the open air, and indicate that the greater number of the eggs are deposited during the months of May and June, although a few may be found as early as the last week in March and as late as the first week in September; outside of this period but few eggs of this species will be found. Although this

species is quite generally known as the Black Scale, still this term is an evident misnomer, at least as far as some specimens of this scale are concerned. On the 16th of April, 1890, Mr. F. O. Cass, of this city, brought me several leaves and twigs of Oleander upon which (paradoxical as this may seem) were three Black Scales of a uniform white color; some of the other scales were dark brown, while the remaining ones were of the normal brownish-black color. I submitted them to Prof. Riley, and under date of April 23, 1890, he wrote me as follows in regard to them:

I have received a box containing white "Black Scale." I feel sure that this is *Lecanium oleæ*, but do not recollect that I have seen anything like it before. It is more probably to be accounted for as a case of albinism, which is the only case I know of in Coccids. Lecanium does not molt in this way.

I have never observed this characteristic in any other kind of scale-insect, and it appears to be of rare occurrence among the individuals of the present species.

The young of Black Scale after issuing from the eggs usually remain beneath the body of the parent for several hours, finally crawling out and taking up a position on some other portion of the plant; they do not settle down in one place permanently, but change about as circumstances may make it necessary. I have seen half-grown individuals thus crawling about. As a rule they infest only the leaves and bark; only in rare instances do they attack the fruit. The eggs first laid are hatched out before the last egg is deposited, and thus the processes of deposition and hatching proceed simultaneously until the last egg has been deposited. The number of eggs deposited by a single female is simply enormous; as stated above, I counted beneath one of them over 2,200 eggs and young larvæ, all of which were undoubtedly the progeny of this female.

Among the insect enemies of the Black Scale may be mentioned the Twice-stabbed Ladybird (*Chilocorus bivulnerus* Muls.), the larva of which I have repeatedly caught in the act of feeding upon these scales. I have also seen the larva of the Tineid moth, *Blastobasis iceryæella* Riley, feeding upon these scales. I find by reference to my note book that on the 11th of March, 1887, I found a larva of this species beneath three empty full-grown Black Scales on an olive tree; this I transferred to one of my breeding cages, in which I placed a branch of an olive tree upon which were Black Scales of all sizes. A few days later I examined this cage and found that the larva had spun a thin, loose silken web over some of the Black Scales and had partially devoured several of the half-grown ones. This larva had changed to a chrysalis when examined on the 4th of May following and the moth issued May 28. A full description of this insect will be found in the Annual Report of this Department for 1886 (pp. 484–486), and a figure of the moth is also given at Fig. 3, Pl. III, of the above-mentioned report.

By far the most effectual destroyer of the Black Scale, however, is a

small, four-winged Chalcid fly known as *Dilophogaster californica* Howard. A description and figures of both the male and female of this useful parasite will be found in the Annual Report of this Department for the year 1880, p. 368, and Pl. XXIV, Figs. 3 and 4. The name Tomocera, under which this insect was described in the above-mentioned report, was found to have been previously used for another group of insects belonging to the order Thysanura, and the name Dilophogaster was therefore substituted for it. I have quite frequently found orange trees upon which fully 80 per cent of the adult Black Scales had been destroyed by these parasites. I find by reference to my note book that I bred parasites of this kind on the 14th and again on the 27th of June from Black Scales collected on the 25th of the preceding April; and that on the 22d of September I found a full-grown larva of this parasite under an adult Black Scale. I also captured specimens of this Chalcid on the following dates: January 17, July 2, August 31, September 21, and October 12. This would seem to indicate that at least two and perhaps even three generations of these parasites are produced in one year.

It is to be regretted that these useful parasites sometimes fall a prey to other insects, but such is the case. I find by reference to my note book that on the 21st of September I saw a larva of a slender greenish bug known as *Diplodus renardii* Hol. engaged in feeding upon one of these parasites; the beak of the larva was inserted into the body of the Chalcid fly and the juices of the latter had been nearly extracted by the voracious captor. Fortunately, these predaceous insects are not abundant. I have occasionally seen them preying upon other kinds of Chalcid flies besides the Dilophogasters; on the 1st of September I captured one of the adults which had its beak inserted into a *Perilampus* sp., one of the Chalcid parasites of the Lace-wing referred to above in the chapter treating of the Red Scale; the Diplodus held the Chalcid beneath his front feet, somewhat as a dog holds a bone while gnawing it. I have occasionally found the square or roundish egg masses of this Diplodus attached to the upper surface of the leaves of orange trees; each mass contains from thirty to forty eggs which are regularly arranged in rows, the eggs in one row alternating with those on either side of it. Each individual egg is nearly cylindrical in form, of a honey-brown color, except the top, which is white, and near its center is a small puncture as if made with the point of a needle. The mass is fastened to the leaf by a very sticky substance, which, however, does not hold it firmly, and the egg mass may be easily removed from the leaf with the thumb and fingers of one hand. The adult Diplodus measures nearly half an inch in length, is rather slender, and of a yellowish-green color variously marked with black and yellow.

Notwithstanding the immense numbers of Black Scales and their eggs which are annually destroyed by the Dilophogasters, still these scales frequently become so abundant as to render it necessary to em-

this tree were very thickly infested by the scales, indicating that the tree is perfectly congenial to their tastes and requirements.

In the above-mentioned account I stated the fact that at that time no insect was known to attack these scales, but since this was written I have bred from them numerous specimens of a small Chalcid fly, known as *Coccophagus lecanii* Fitch. These attack only the younger scales, and only one of the parasites infests each scale, causing the latter to assume a more convex, much smoother form than when not parasitized, and the entire upper portion of the parasitized scale becomes black.

The Brown Apricot Scale.

(*Lecanium* sp.)

In the Santa Clara Valley, south of San Francisco, occurs a species of Lecanium which is sometimes very destructive to various kinds of deciduous trees. On the 21st of March of the present year I received specimens of these scales from Mr. F. M. Righter, an extensive grower of deciduous fruits located in the above-mentioned valley. The scales were of two sizes, representing two different generations, the old dead and dry females and the nearly half-grown young ones. A careful examination of these specimens convinced me that while they were evidently closely related to the Frosted Scale of the preceding chapter, still they evidently belonged to a distinct species. The more marked differences consisted in the smaller size of the adult females, the fact that they never became covered with a whitish powder, and the further fact that the younger ones are destitute of the submarginal row of long bristles which occur in the young of the Frosted Scale.

In the letter which accompanied these specimens Mr. Righter writes as follows concerning them:

> I send you by today's mail specimens of the Brown Apricot Scale, so called, notwithstanding they infest prune trees as much or more than apricot. They are also found on peach, pear, apple, and cherry, but principally on apricot and prune. * * * I think they are not the same as the Brown Scale you mention; they are never covered with a white powder.

Thinking that perhaps the submarginal bristles may have existed in perfect specimens of the young scales but had been accidently broken off of the specimens sent me through the mails, I requested Mr. Righter to examine the young scales fresh from the tree and ascertain if these submarginal bristles existed upon them; and under date of April 18, 1891, he writes me as follows:

> I have a microscope of very high magnifying power, and have carefully examined both the young and the full-grown scales, and find that neither of them are provided with bristles around the edge of the body. Nor can I find any as large as you mention, *i. e.*, seven twenty-fifths of an inch in length; the largest I can find measure seven thirty-seconds of an inch in length.

Again, under date of May 12, he writes as follows:

> The Brown Apricot Scale seems to have completed its work. Its eggs are laid, and it is seemingly wholly inactive.

The largest adult specimens received from Mr. Righter are 4^{mm} long by 3 wide and 1¾ high, and the smallest adult specimens are 3^{mm} long, 2 wide, and 1 high; the color is a light yellowish brown, the outline oval, narrowing anteriorly; the sides are rugose and transversely carinate, the dorsum much smoother, and with indications of a medium carina most distinct anteriorly; the edges are thin and spread out.

My library contains references to upwards of fifty descriptions of as many different kinds of Lecanium, and it is quite impossible to decide to which of these numerous species the Brown Apricot Scale belongs.

As a remedy, the stronger resin wash described in the chapter on the San José Scale will doubtless be found effectual when used against the present species; it should only be used while the trees are dormant, and at that time none but the younger scales will be found alive, there being but a single generation each year. Common brown laundry soap, 1 pound dissolved in 3 gallons of water, will doubtless prove fatal to these scales, as I have known it to do when applied to the common soft Brown Scale.

THYMO-CRESOL AS AN INSECTICIDE.

Some time during the past summer I received a can of thymo-cresol for experimental purposes. No opportunity occurred for testing this insecticide until on the 4th of September, at which date I sprayed some of the diluted liquid on an orange tree infested with the Yellow Scale (*Aspidiotus citrinus*) and with the Soft Scale (*Lecanium hesperidum*). I used it in the proportions of 1 gallon to 1,000 gallons, and also to 2,000 gallons, of the wash, these being the proportions recommended for destroying scale-insects on orange trees as given in the circular which accompanied the can of insecticide. The weaker wash did not prove fatal to a very large percentage of the scales, but the stronger one destroyed about 90 per cent of them; there were very few of the soft scales on this tree, but all of them were destroyed by the wash, while the fruit and leaves were not injured. In the printed directions it is recommended to syringe the trees with pure water fifteen minutes after applying the wash, but this I did not do, since it would occasion too much labor to carry out this plan in the case of large orange groves.

According to a schedule of prices which accompanied the can, a 3-gallon can of the thymo-cresol costs $5.25; at this rate, each gallon of the stronger wash used above would cost somewhat less than one-fifth of a cent per gallon, which would make this an extremely cheap insecticide.

In the printed directions it is recommended to make three applications of this wash, at intervals of eight or nine days, each application to be followed by a spraying with pure water fifteen minutes after the application is made; this plan might be followed in regard to a few plants or small trees, but it is altogether too expensive for adopting in the case of large orange groves.

ENTOMOLOGICAL NOTES FOR THE SEASON OF 1891.

By Mary E. Murtfeldt.

LETTER OF SUBMITTAL.

Kirkwood, Mo., *October 31, 1891.*

Sir: I herewith inclose a record of some of my observations and experiments for the past year relating to economic entomology.

Respectfully yours,

Mary E. Murtfeldt.

Dr. C. V. Riley,
Entomologist,
U. S. Department of Agriculture.

Taking one locality with another, this State may be said to have suffered less from the ravages of insects during the season of 1891 than for many years previous. The climatic conditions from early spring until the middle of August, a period covering the growing season of the most important crops, was exceedingly favorable to the perfection of vegetation. As a consequence, the yield of grain, hay, fruits, and many sorts of vegetables has been abundant and the quality unsurpassed.

In certain localities there were irruptions of injurious insects which for a time caused anxiety, but these were, as a rule, over limited areas, and the aggregate of loss occasioned by them was less than had been anticipated.

The most annoying pests of the spring and early summer were Aphididæ of numerous species. The punctures of the fruit-infesting forms produced on the new growth of grapes, peaches, and plums considerable blight and deformity.

The Woolly Aphis of the Apple (*Schizoneura lanigera*) is an almost invincible enemy of young orchards in some sections of the State, especially on gravelly soils. On such specimens of diseased roots as were sent to me I could find no trace of parasites or other natural enemies. Drenching with strong, hot soapsuds was recommended, and was reported as quite successful in checking the work of the insect, but in some of the orchards the roots were so warty and diseased that recupera-

tion was impossible, and uprooting and burning the trees seemed the only advisable plan to pursue.

The Grain Aphis (*Siphonophora avenæ*) was sent to me from several localities, but its appearance was by no means general, and the oat crop, which in Missouri suffers most from this insect, was good in almost all parts of the State.

The Chinch Bug (*Blissus leucopterus*) appeared in considerable numbers in the western and southwestern parts of the State, first on wheat, which it did not materially injure, and later on corn, some fields of which were seriously damaged. The dissemination of the germs of so-called "chinch-bug cholera," by Prof. Snow, of Kansas, and Prof. Forbes, of Illinois, was actively carried on, and the confidence of farmers in this natural remedy for the most serious pest of their grain fields was proved by the extent of the demand for the diseased bugs. Probably not all made use of the latter in a way to accomplish the ridding of their fields of the bugs, but so far as I have been able to learn a very encouraging measure of success attended the introduction of the disease germs into infested wheat and corn fields.

The Joint-worm (*Isosoma grande* Riley) appeared in several sections of the State about the first of June and excited much apprehension for the safety ot the wheat crop. In the samples of grain sent me the larvæ were invariably working in the heads, then just in bloom. None were found in any of the lower joints. Infested heads were, of course, utterly destroyed, as from three to six worms were often found in one head. Mr. J. F. Iles, of Lexington, found about 80 per cent of the heads injured in a certain field, and anticipated the loss of his crop, but later he informed me that the damage was mainly confined to a portion of a field that had been planted on wheat stubble of the previous year. The specimens reared from larvæ sent me were all females, and but one head contained pupæ that had the appearance of being parasitized, but I was not able to obtain the flies of the latter.

The Plum Curculio (*Conotrachelus nenuphar*).—Notwithstanding the almost total failure in this locality of all cultivated and most of the native stone fruits, for the two preceding years, this hardy and adaptive insect presented itself this season in sufficient numbers to inflict considerable damage upon the sweet cherries, early plums, and freestone peaches. On the latter, however, its work was not disastrous, and the later varieties escaped with very few punctures. The fruit that tided it over last year was probably the Wild Black Cherry (*Prunus serotina*) and possibly some of the pip fruits, although I have never reared it from any of the latter. I have, however, repeatedly bred it from larvæ in gooseberries.

The Harlequin Cabbage Bug (*Murgantia histrionica*) was not only unusually destructive to cabbage, cauliflower, and other cultivated Cruciferæ, but in the southern counties attacked beans, peas, and several other sorts of vegetables. This pest seems to be steadily advanc-

ing northward and has now reached about the middle of the State, having been sent to me from Phelps, Washington, and Boone counties. The mature bugs are long-lived, and my correspondents claim that eggs, young larvæ, nymphæ, and perfect insects are contemporaneous throughout the season, and that wherever they abounded the cabbage crop was almost, or quite, a failure. With a view to test insecticides upon them, I obtained in July, from Phillipsburg and elsewhere, several lots of the mature insects. Many of these had deposited their beautiful egg-clusters in the boxes by the time they reached me. There was considerable variation in the intensity of the markings of these eggs, some being very dark, while others had the black lines but faintly indicated, and one set of about a dozen was entirely pearl white. The young bugs hatched in the course of two or three days, emerging through the lids of the little "barrels," which were lifted on one edge, the shell retaining its form and ornamentation after giving up its inmate.

Part of the young bugs were transferred to plants in the garden confined under wire screens, while others were retained in the breeding cages.

The insecticides experimented with were X. O. dust and Pyrethrum, neither of which made much impression, and arsenites of ammonia in the proportions of two tablespoonfuls to a gallon of water. This killed some of the young bugs, but also severely burned the plants, and would not, in any case, be safe to use on such a vegetable as cabbage. Kerosene emulsion killed the young bugs but did not affect those that were full-grown. Thymo-cresol—one part to thirty of water—a very strong solution, was also of no avail. Hot water was then used, taken boiling from the range, carried about 100 yards to the garden, transferred to the sprinkling can and immediately applied to the infested plants. The temperature was not taken, but it could not have been much below 150° Fahr. The plants were but slightly wilted, and the bugs were all killed. In this experience all my correspondents who have tried the remedy concur. The only difficulty is to bring this, or any other application in contact with all the insects, as they seem to prefer feeding on the undersides of the leaves. But if the drenching with hot water be supplemented by careful hand-picking, two or three times during the season, the pest may be temporarily eradicated.

Cutworms this season gave far less trouble than usual. I am convinced that warm, wet winters do not agree with them. *Nephelodes violans* was the only abundant species. This was found in hay fields eating the stalks and blades of timothy grass.

Orsodachna atra Ahr.—This Chrysomelid was observed early in April, on the grounds of a neighbor, swarming on the blossoms of the peach. It would crowd into the unfolding buds, tear open the anthers, and devour the pollen proceeding from blossom to blossom with great rapidity, destroying every anther in its progress. In their haste and

greed these beetles would accumulate considerable pollen on their heads and fore tarsi, and it is probable that some of this was brought in contact with the stigmas, but there was every reason to fear that they would devour the lion's share of the golden grains and that the ovules would not receive enough to fertilize them. A few days later I found a considerable number of the same beetles at work on an isolated tree on our own place, and as the variety of peach was not very choice, it afforded a good opportunity to test the result of the insect attack. They were accordingly suffered to cut as many anthers as they would. As a matter of fact, this tree, though young, vigorous, and favorably situated, and covered with blossoms in the spring, bore very little fruit, while others of the same variety, on which Orsodachna had not been seen, produced abundantly. Should it become a pest in future years, its habit of dropping to the ground when disturbed would enable fruit-growers to destroy it by jarring it down upon cloths or trays moistened with kerosene.

The Cottony Maple Scale (*Pulvinaria innumerabilis*).—The vanguard of the hosts of this pernicious Coccid appeared again in St. Louis during the past summer upon the trunks and branches of various trees and shrubs in the parks, and in many private grounds, and unless timely attention is given to the matter it will next year prove as annoying and destructive as it was six or seven years ago.

The Post Oak Coccid (*Chermes* sp?).—The clusters of globular female scales of this insect were to be found in the axils of almost every twig and leaf of the Post Oak (*Q. obtusiloba*) during the past summer. These, in connection with an undetermined fungous disease, produced a remarkable blighting of the new growth, and in a number of cases seemed to be the cause of the death of the tree. So noticeable was the effect in the forests around Kirkwood that many people contended that it was "locust year," and wondered why we had not noted the shrilling of the Cicada. It was with difficulty that I could make them believe the contrary.

My attention was not attracted to this insect sufficiently early in the season to enable me to observe its development, and at present the scales contain only a mass of empty shells or skins. No guest insects were bred from them during the season.

The White-marked Tussuck-moth (*Orgyia leucostigma*).—The larvæ of this insect were very destructive to the foliage of Willow, Walnut, Chestnut, Maple, and some other shade trees of the streets and parks of St. Louis, as well as to Apple and Plum in private grounds, but I noted in it a habit which will (or might) enable those suffering from its ravages to destroy a large proportion of the eggs, namely, the trapping of a great number of the caterpillars as they were seeking a hiding place in which to spin, by the cotton bands with which so many of the trees that shade the sidewalks are encircled. Some of these bands that I have examined have been quite crowded with the chrysalids and egg-

masses of the insect, and, if removed and burned before spring, will certainly prevent the development of myriads of the pest. From young larvæ sent to me last spring I reared several parasites (*Limneria flavicincta*, Ashm.), but these were not sufficiently numerous to materially reduce the numbers of the host insect. If the infested trees be sprayed with Paris green, in the proportion of 1 pound to 300 gallons of water, or a very dilute solution of arsenites of ammonia, 1 pint to 100 gallons of water, the insects will be killed without injury to the foliage of any tree.

Chamyris cerintha Treat.—The singular larvæ of this beautiful moth were taken this summer feeding on the foliage of the Damson Plum. They devour the leaf on both sides to the mid-rib, leaving the latter. I think they have not heretofore been recorded among insects that depredate on the foliage of fruit trees.

Catocala grynea is becoming with us quite a serious orchard pest during the latter part of May and June. The larvæ rest during the day, closely appressed to the trunk and larger branches, and feed at night. Spraying with Paris green is an effectual remedy.

Edema albifrons, which has not been found here for a number of years, made a serious attack on the white and post oaks early in the summer, inflicting considerable injury on the foliage. No experiments were made in the application of artificial remedies.

SOME OBSERVATIONS ON THE FOREST TENT-CATERPILLAR.

While on a visit to Minnesota in May I had an opportunity of witnessing a remarkable outbreak of the above-named insect (*Clisiocampa disstria* Hbn.). In all the forests around Minneapolis, and especially on the fine trees along the shores of Lake Minnetonka, the oaks, elms, lindens (*Tilia*), and ash trees were entirely stripped of their young leaves, the larvæ migrating from tree to tree as fast as the latter were defoliated. Many would descend by the trunk, but a large proportion preferred to leave the tree by means of silken ropes, often stretched from the highest branches to the ground, and which, by the thread contributed by each descending worm, became eventually as thick as packing cord and very strong. Down this the worms crawled in single file. In driving along the woodland roads these long swaying strings of worms presented a most singular spectacle. Occasionally one of these ladders would be carried by the wind (or possibly by the accidental impact of a bird) from one tree to another, and even across the roads, forming festoons of crawling worms through which it was anything but agreeable for nervous people to drive.

The few orchards of that part of the country were also badly infested by the same species.

I could not observe much of the tent-making habit. Even when molting in companies the larvæ merely spun mats of silk against the

bark of the tree and in very few cases was there any attempt at a shelter.

From accounts in the papers of that date it would seem that the insect prevailed throughout the forests of the Northwest, and in some instances, while moving in armies from one locality to another, they were so numerous on railroad tracks as to occasion delays and stoppage of trains. Poultry refused to feed upon them, and, so far as I was able to observe, very few birds attacked them. My stay was not sufficiently prolonged to enable me to ascertain what proportion of the larvæ were destroyed by parasites. I was informed by friends who were summering at Lake Minnetonka that one still, warm evening early in July all the moths seemed to issue at once and were so numerous that the fluttering of their wings up and down the trunks of the trees and among the branches filled the air with a distinct and peculiar humming sound that attracted very general attention and curiosity.

On the succeeding evening scarcely a moth could be seen, and it was supposed that the brisk wind that blew during the day had carried them into the lake. So far as I could judge by their behavior in the rearing cage, they develop with remarkable regularity, hatching, molting, and transforming simultaneously, so it is probable that in one or two evenings of winged existence they had fulfilled their mission of providing for the continuance of their kind.

NOTES ON SOME NATURAL ENEMIES OF PERNICIOUS INSECTS.

The Web-worm Tiger (*Plochionus timidus*) (if I may be permitted to give it a popular name) realized all that was anticipated of it this season in its work of exterminating the insect it has selected for its special prey.

June 6 I found two colonies of *Hyphantria cunea*, one on a young tree of Box Elder and the other on a vigorous sprout of Laurel Oak, both in excellent position for observation *in situ*. The larvæ in each case had inclosed but two or three leaves and seemed to be about ready for the first molt.

On the 10th a single specimen of Plochionus was observed running up and down in each of these webs. On the 16th a close examination of the nest revealed a dozen or more of the slender white eggs attached to the twigs and petioles of the leaves and a few laid loosely in the web. On the 20th larvæ about 3^{mm} in length were seen in the web and probably others had attached themselves to the Web Worms, now about 11^{mm}, or one-half inch in length.

When next visited, June 23, the colony on Box Elder had migrated and separated into three companies on different parts of the tree. They had not, however, in this way escaped their relentless foe, for a number of the active little Carabids were running about among them apparently quite at home wherever the worms were. Two were seen

with their jaws buried in the bodies of the Hyphantria larvæ just back of the head.

June 27, the presence of this savage and persistent enemy seemed to utterly "demoralize" the web worms, causing them to repeatedly "break up housekeeping" and seek new locations, separating into smaller and smaller groups in the instinctive search for safety. But the attempt is vain; for no sooner are they established than Plochionus is on the trail, and is not long in discovering their whereabouts and biting into them whenever it is hungry.

By the end of June the colonies on both trees, though not nearly full-grown and greatly reduced in numbers, had dispersed, the gregarious instinct having evidently been lost much sooner than usual. A few Plochionus larvæ about one-half size were to be seen in the deserted webs for a day or two after the web worms had disappeared, after which they, too, departed, and I presume descended to the ground, where they preyed upon such larvæ as could be found there. A few were placed in a rearing jar and supplied with Spilosoma, Orgyia and other hairy larvæ, but these were not attacked, nor was I able at the time to find any other species upon which they would feed, and all perished without completing their development.

The second brood of Hyphantria, which with us has always been most numerous and injurious, was very sparsely represented in this locality. Upon my return from the East I made diligent search in Kirkwood and vicinity for the remains of webs or other evidence of the worms, but could find very few. To my mind there is no question that this happy immunity is due primarily to the agency of the little Carabid, which has in some way suddenly acquired the habit of preying upon them.

Uropoda americana.—About the middle of July I received from Mr. F. M. Webster a few specimens of the Striped Cucumber Beetle (*Diabrotica vittata*), thickly infested with the above-named large brown mite, with the request that I attempt to colonize it on the same or allied species of beetles here. Just at that season I could find but very few examples of *D. vittata*, but as *D. 12-punctata* was abundant I hoped the mites would accept the latter as a substitute. In this I was disappointed, the parasites refusing to leave their original hosts. After a few days two or three specimens of *vittata* and several each of *Colaspis prætexta*, *C. tristis*, *Lema trilineata*, and *Doryphora 10-lineata* were introduced into the jar and each supplied with its preferred food. The jar—a large one of clear glass—was kept on my desk under constant observation, and in two days I noticed a few of the mites on each species of Colaspis, with a very evident preference for the pretty blue *tristis*. In the course of a week all the specimens of the latter were thickly covered and much weakened, while only a few were found on *prætexta* and none at all on any of the other species, not even on the fresh specimens of their original host. In accordance with a suggestion, the attempt was made

to colonize them upon *Anasa tristis* and other Hemiptera, but without success.

A few of the mites had, when first received, been introduced into the cucumber bed, and upon leaving home in August I transferred all the beetles to the garden in the hope that they would disseminate the parasite. To what extent this has been done I can not now say. Upon my return home, after an absence of a month, I found the garden suffering from heat and drought, the cucumber plants nearly all dead, and no mite-infested beetles to be seen. I hope, however, that Uropoda may reappear next season in time to save us, in a measure, from the attacks not only of the cucumber beetle, but from those of Colaspis on flowers and grape foliage, on which both the bronze and the blue species have for several years inflicted much damage.

The Cabbage-worm Parasite (*Apanteles glomeratus*).—It is with great satisfaction that I announce the advent into Missouri of this valuable natural check to the ravages of *Pieris rapæ.* It was observed about the 1st of August in the gardens of Kirkwood, and about the same time was reported to me by Mr. C. P. Fox, of the experiment station at Columbia, in this State. Mr. Fox claimed that in his locality it had destroyed about 80 per cent of the worms. Unfortunately many of the cocoons received from this gentleman were infested with a secondary parasite (*Tetrastichus* sp.?) which may interfere somewhat with its future abundance. In this vicinity the primary parasite was unmolested, but was not so numerous as at Columbia, not more than one in five or six of the worms being affected. It was found, also, upon two larvæ of *P. protodice*, which in our garden were feeding upon Sweet Alyssum. It has been several years since I found the latter larvæ upon cabbage. In some unexplained way *P. rapæ* seems to have driven them from the field.

I have not yet learned how general the appearance of the cabbage-worm parasite was during the past summer in this State, but, judging from the fine crop of cabbages sent to our city markets from the northern and western counties, the vegetable must have been rescued by some natural agency from its most serious enemy, and this agency, I strongly suspect, was the little Apanteles under consideration.

INSECTICIDES.

The only new preparation experimented with this summer was "Thymo-cresol," Lawford Bros., importers, Baltimore, Md. This fluid is offered to the public more especially as a "cold-water dip" for sheep and for use on poultry and other animals in the case of vermin. It is also claimed to be a valuable disinfectant and antiseptic. In accordance with instructions from the Department it was tried as an insecticide in the place of kerosene emulsion. Added to 50 parts of water it forms a milk-white, soapy fluid that distributes readily through the Lewis hand sprayer. It has no disagreeable odor, a point that counts

in its favor, and is not irritating to the skin, nor in any degree poisonous.

The first use made of it was against that worst of all poultry pests, the Chicken Louse (*Goniocotes hologaster*). This is a minute creature, much resembling the Red Spider so injurious to plants. It is often found in birds' nests and is probably in this way communicated to chickens. In the case in question these lice not only appeared in the chicken house, but invaded the adjacent stable, where they proved extremely irritating to not only the horse, but to the person in charge. As soon as the matter was mentioned at the house measures were taken to exterminate the pest. The chickens and other animals were excluded from their usual quarters and the buildings fumigated with burning sulphur. This was followed by a thorough dusting with air-slaked lime, usually a dependable remedy. In this instance, however, these measures did not suffice to expel all the lice, and complaints of the nuisance continued. As a last resort the Thymo-cresol, a package of which had just been received, was recommended, and a large quantity ot water was prepared with the proportions of the remedy according to instructions. With this the chicken house, inside and out, and the entire stable was thoroughly drenched by the aid of the appliance mentioned above, and there was no further trouble with the louse.

As a disinfectant its use was continued throughout the season in the barn and outbuildings.

As an insecticide my experiments would not justify me in recommending it for general use. It was tried upon the beetles and larvæ of the Potato-beetle; upon the Squash Bug (*Anasa tristis*); upon the Twelve-spotted Cucumber Beetle (*Diabrotica 12-punctata*); upon the Harlequin Cabbage Bug (*Murgantia histrionica*), and upon a number of other Coleoptera and Hemiptera without appreciable effect. Various Aphididæ were destroyed by repeated applications; the larvæ of the Cabbage Butterfly were also sickened by two or three doses, but a single wetting did not suffice to do much good; a strong solution—1 part to 30 of water—was used upon Harris's Apple Scale (*Chionaspis furfurus*) and upon the Rose Scale and seemed to penetrate to and destroy the eggs; but on the whole it is not sufficiently drastic to kill at once by contact, and is not speedily poisonous to vegetable-feeding insects if taken in with the food. Its effects on vegetation are not injurious, except when a number of applications are made in succession without spraying with pure water to rinse it off. I hope to repeat and extend experiments with it another year, especially to give it a thorough trial on animal parasites, for which but little opportunity offered the present season.

REPORT OF PROGRESS IN THE INVESTIGATION OF THE COTTON BOLL WORM.

By F. W. MALLY.

LETTER OF SUBMITTAL.

SHREVEPORT, LA., *October 9, 1891.*

SIR: At your request I have hastily prepared a very brief and condensed summary of this season's work, carried on under your direction, upon the Cotton Boll Worm (*Heliothis armigera* Hübn.).

All details as to experiments, observations, and special notes have been omitted, as the summary was only to give an adequate idea of the present condition of the investigation.

Very respectfully, yours,

F. W. MALLY,
Assistant.

Dr. C. V. RILEY,
Entomologist.

GEOGRAPHICAL DISTRIBUTION AND DESTRUCTIVENESS.

The Boll Worm is found throughout the whole cotton region. Over the greater portion of this area its injury is only slight and not worthy of special economic consideration. The regions where special remedial or preventive measures are practicable comprise that portion of Texas included by an irregular line drawn from Paris to Tyler, to Cameron, to Temple, to Gainesville, to Paris. For Arkansas a narrow belt from Fort Smith to Morrillton, to Little Rock, to the southeastern portion of the State For the Indian Territory a strip running from Gainesville, Tex., to Fort Smith, Ark. These are the areas of greatest destructiveness, and for the whole area the injury may range from 10 to 15 per cent of the whole crop. For certain counties the percentage of injury is greater. Again, individual plantations may be almost wholly destroyed while a dozen others adjoining may escape with only slight injury. The sensational reports of damage are nearly always based upon these individual examples, and an accurate scientific estimate of the average for a county or district is seldom made. The worst infested fields are, in most cases, those which for some of many reasons which could be given in a detailed report behind the others; that is, late cotton. This makes them

more attractive to the moths and accounts, in part, for the fact that one field is badly injured while surrounding ones are not. The injury in other portions of the cotton region not specially outlined above amounts to less than 2 per cent, and is so scattering as not to demand serious attention, unless, perhaps, in a few isolated exceptional localities.

FOOD-PLANTS.

Corn is well known as its choice food-plant. Cow-peas rank next, and cotton probably third, though there is evidence that if the tomato crop were in as prime a condition later in the season when corn matures the tomato would rank third, and cotton, at best, about fourth. This accounts in part for the slight injury to cotton over most of the cotton belt, where many of the crops just mentioned are planted a second time later in the season, and which, therefore, divides the attack of the Boll Worm on cotton. Experience has abundantly shown that cotton as a food-plant is more a compulsion than a choice. More stress should be placed upon the importance from an economic, entomological standpoint upon the many host plants already on record for this species. In localities where the cultivation of tobacco is being introduced it is to be noted that the Boll Worm abundantly attacks the crop, and care must be exercised in order that its ravages may not attain serious proportions and endanger the progress of the introduction of this crop. In large cities even flower gardens entirely isolated from corn or cotton fields, have been frequently found to be infested with Boll Worm. This can not be accidental, as might be urged, if these gardens were exposed to badly infested fields, and it simply illustrates the reckless, apparently indifferent habit of the female as to the host plant upon which she deposits. Special mention in city flower gardens should be given the Verbena, Geranium, Abutilon, rosebuds, and Jack Beans.

CHARACTERS AND TRANSFORMATIONS.

These have been so fully described heretofore that nothing further deserves special mention in this connection, except the habit of cannibalism among the worms. As for the imagos, former observations as to their diurnal habits have been fully verified the present season. At Arlington, Tex., last August, hundreds were seen flying and feeding freely on cow-peas from 9:30 to about 11 a. m. Though carefully watched, deposition at this time was not observed, and it appeared that they were only breakfasting. Deposition, however, could be frequently noted in the afternoon several hours before sundown.

NUMBER OF BROODS AND HIBERNATION.

As to the number of broods nothing additional need be mentioned at this time. The question of hibernation, however, demands special consideration, and steps must yet be taken to determine more definitely

the facts. Your agent, unfortunately, has been located in regions not especially infested, and it transpires that owing to the scarcity of adults at any season in the localities under observation that hibernating specimens would be rarely found.

There is no question but that many pupæ do not issue in the fall, but remain as such over winter. Many of these even enter the pupa state as early as the middle or latter part of September and remain quiescent until April or May. The decided overlapping of the broods from the beginning of the season is thus easily explained, for doubtless the hibernating moths appear earlier than those issuing from the pupæ in spring.

Observation proves beyond a doubt that a great majority of the destructive brood on cotton in August and September issue as imagos before the close of the season. The facts also prove that instead of the number of worms which might rightfully be expected from these imagos to appear in greatly increased numbers absolutely appear in decreased numbers. This indicated that some of the moths of this brood were bent upon hibernation and refrained from depositing at this time. Indeed, the facts disclosed by the latest observations warrant the assertion that many of the imagos resulting from this destructive brood hibernate. The majority of the worms spoken of in previous reports as found so late in the season are mostly those from the eggs of belated females of the preceding brood and worms whose most rapid development has been hindered by various, perhaps accidental, unfavorable environments. Furthermore, as previously stated, the broods from the very first of the season overlap. Doubtless, therefore, a great portion of the worms found during the latter part of September and later consist also of the lap, so to speak, of the last brood, and should not be counted as a separate brood or even a partial one.

NATURAL ENEMIES.

The cannibalistic habit of the Boll Worm makes it its own greatest enemy, as will be shown under the head of remedial measures. All the enemies noted in Bulletin No. 24 of the Division have been observed again. The same special stress and importance must again be repeated in speaking of the egg parasite (*Trichogramma pretiosa*). Its value can not be overestimated. Among birds the Sapsucker, Crow Blackbird, and Crows deserve special mention. Another species of Robber Fly was noted catching the imagos. Observations upon the habit of ants (*Solenopsis geminata*) earlier in the season makes it absolutely certain that at that season they frequently capture a Boll Worm. They do so mostly when the worm travels or comes out of the ear of corn to molt. They seldom enter an ear of corn for a deliberate search after their victim. Later in the season, when there is a greater diversity of insect life and also vegetable growth, the ant loses special interest in the Boll Worm.

A small Capsid (*Triphleps insidiosus*) is found abundantly on corn silks. It punctures and feeds upon the eggs of Heliothis and probably very young Boll Worms. Many beneficial insects, especially the small Scymnid beetles, are also abundantly found on corn silks. This subject will, however, be treated more fully in a subsequent report.

INSECT RAVAGES EASILY MISTAKEN FOR THOSE OF BOLL WORM.

All of those noted in Bulletin No. 24 of the Division have been observed again, with the additional one of *Thecla pœas*, which, however, had been previously recorded. Among the Tortricidæ, a number of species have been reared on cotton. The habits of the larvæ are well known to be such that it is reasonable to expect that those species of Pyralidæ and Tortricidæ which feed on cotton at all may occasionally in doing so bore a stem or peduncle, or even the bolls, forms, and squares themselves.

Many Hemipterous insects puncture very young forms and squares, or their peduncles, causing the prospective fruit to fall. The mark resulting from the puncture closely resembles the working of very young Boll Worms, and by many planters the latter are held responsible for the injury. To Hemipterous insects is due much of the shedding of cotton in August and September, and ravages are popularly called "sharpshooter" work. The most injurious, and perhaps also the most abundant of the sharpshooters is a large leaf-hopper (*Aulacizes* sp.). *Calocoris rapidus*, *Largus cinctus* are among those also which do much damage. The life-history and ravages of these insects must be reserved for more complete discussion in a subsequent report.

REMEDIES.

The great range of food-plants of the Boll Worm, its habit and method of feeding upon special portions of these host plants, together with the isolation of individuals which necessarily follow such food-habits, make all insecticidal measures of any nature little of or no practcial utility. In the regions designated heretofore as injured probably about 2 per cent or less, the attack by the Boll Worm is divided between so many different crops that the application of any insecticide upon one crop becomes much more expensive for that crop than the injury done by the worm. Furthermore, such measures are inadequate unless applied to all the crops attacked at any specified time in any given locality. For these regions it is evident, therefore, that insecticidal measures are entirely impractical, even though the insecticide be a perfectly efficient one and can be applied with the greatest effect. The same can be said for localities worse infested, though the difference in destructiveness partly mitigates the excess of expense. In any case, the vast areas of cotton to be treated in addition to other crops still make such measures questionable as to expense, aside from the time required during the

busy season when such remedies must be applied. It is the opinion, therefore, of your agent that no insecticidal measures, even though efficient as such, are to be recommended, because from the nature of the case they are burdensome and impracticable. The whole work must be accomplished by preventive measures, such as are hereinafter discussed, and which have been suggested by the food-habits of the species in question, and which by experiment have been found adequate. In this way it was determined that the Boll Worm has a choice food-plant among the long list recorded, and, as will be seen, it has been the effort of your agent to demonstrate the practicability of manipulating this food-plant so as to concentrate the attack upon it, first trapping the worms and then destroying them.

PLOWING.

Fall plowing, as a preventive measure against Boll Worm in slightly infested regions, is not practical as a purely boll worm measure. In badly infested regions it is to be done when possible. The great difficulty with this measure is that the top crop of cotton is seldom all picked timely enough to make fall plowing possible before the rainy, wintry season begins. Due to this fact, it must be urged that plowing be done in spring, as early as it is possible to plow and pulverize the soil. This early plowing, with the cold, rainy weather and occasional frosts, which occur as late as April 1, will insure the destruction of many of the chrysalids. The after-preparation of the soil at planting time will doubtless destroy a small percentage of the surviving pupæ.

Early plowing, in addition to being a boll worm preventive, has its strong advocates among leading agricultural men, who insist that it should be followed as an improved method or practice of farming, since larger and better crops are produced when done.

CORN.

Corn is beyond doubt the choice food-plant of the Boll Worm. From about the middle of April, when the corn becomes large enough for the Boll Worm to work in it, this worm may be found, and continuously so on through the season so long as green corn in suitable condition for food is found. Until about the middle of May or first of June, Boll Worms are rarely found on any other plants than young corn. This being true it is surprising to find that the first brood is so small. From numerous accurate accounts in May and early June, at Shreveport, La., it was found that about 2 per cent of the young corn plants showed signs of Boll Worm ravage, while (due to the change of plants by the worms) *less* than 2 per cent *actually* contained worms.

At this time there is presented the first and most important opportunity for inaugurating preventive measures, namely: to cut out the infested plants and burn them or simply crush the "bud" of the corn

and mash the worm it contains. The small percentage of corn which, even by the severest method, will be destroyed, together with its absolute certainty in attaining the desired end makes this a cheap, effectual, and practical measure to practice at this season of the year.

Some advise the application of oil emulsions to the "buds" of the young corn plants, but the time required to prepare the emulsions, expense of material and apparatus for applying properly the liquids or powders used, again throws it beyond the realm of the practical. There can be no practical advantage gained since no remedy of this nature can be more satisfactory and expeditious than the practice of crushing or cutting out and burning of the "buds" of infested plants as already described.

This preventive measure has the advantage of being inaugurated at a time when labor is not so much needed for other purposes, and hence can be done at a lesser cost and sacrifice. It can be utilized, however, only during the fore part of the season, before the corn tassels, and hence the importance of early action on the part of the planters at the time specified.

As a second preventive measure the cotton field should be so arranged that four or five rows of corn are planted for every forty or fifty rows of cotton, the corn to be planted at a such a time as to be in the prime of silking and roasting ears a week or ten days after the July brood of Boll Worms matures in the regular crop corn; that is to say, at the time when the moths of the destructive August brood which attacks cotton begin issuing. Finding the regular crop corn too near maturity they are compelled to go to the cotton. This occurs from about the first to the middle of August, depending more or less upon the locality. The important point is to have green corn in suitable condition for food at the time when what is called "the destructive brood" goes to cotton. This time, as is well known, varies some in each locality, and can and must be best determined by the farmers of their respective localities. In most cases the result will be accomplished if the trap corn spoken of is planted from about the first to middle of June.

By some dozen experiments with trap-planted corn in various localities, its practicability as well as efficacy has been demonstrated. The female unquestionably selects the trap-planted corn for egg deposition to the practical neglect of the surrounding cotton and all other food plants except cow-peas. The trap-planted corn being reduced to the minimum quantity, the egg deposition upon each individual ear is unnaturally increased. Oftentimes fifteen to twenty-five or thirty eggs were found on the silks of a single ear. The worms fed and found plenty of room in the ear of corn for a time, but as they grew larger they became crowded and began to prey upon each other. When this preying is once started it is carried to such an extent in these infested ears that rarely more than one (sometimes two) of the twenty or thirty worms ever attain maturity. Those even which attain maturity have yet the risk of capture by natural enemies, parasites, disease, etc., to

experience when leaving the ear and traveling about seeking a suitable place for pupation. The number of ears of corn having been reduced to a minimum by trap planting, it is found that the cannibalism induced among the worms reduces those reaching maturity to minimum also. More than a minimum can not be accomplished, whatever be the remedial or preventive measures. It becomes questionable, therefore, whether it is to be recommended that the trap-planted corn be cut and burned so as to destroy the few worms attaining maturity in it, because the value of the corn more than compensates for the small percentage of worms thus maturing.

Again, the numerous fresh corn silks so late in the season seem to be specially attractive to many beneficial insects as suitable resorts, and the egg parasite and many of the other smaller natural enemies of the Boll Worm are found abundantly on these silks and in the ends of the ears. Whether they are attracted by the corn silks being fresh or in search of the objects of their prey, the fact remains that, being thus conveniently quartered in the trap itself, these beneficial insects have more frequent and better opportunities for successfully preying upon the obnoxious insect. Their attack under such circumstances may be said to be artificially concentrated more or less against a specified injurious insect and hence makes them more efficient agents in reducing and assisting in the control of the ravages of that species. A portion of these beneficial insects would also be destroyed by any treatment of the corn looking to the artificial destruction of the Boll Worm. In view of these additional facts it seems best not to urge such a measure.

As to the first preventive measure, some insist that cutting out infested corn early in the season endangers a good stand. In reply it can be said that, much of the corn being drilled in, some is chopped out at the time of the first plowing. At the time of this first chopping a greater proportion of the drilled corn can be left and at the time necessary to most efficiently attack the Boll Worm the portion cut out will be counterbalanced by the slight excess left from the first thinning. But, as already stated, absolute chopping and burning need not be resorted to if care is exercised so that the crushing process be thoroughly done. In that case the worm is destroyed and the plant, as experiments have shown, is not materially injured and still makes a good ear of corn.

To the second, some object that by planting a trap crop in the manner recommended you actually encourage the greatest possible development in point of numbers, that succeeding broods will be proportionately greater, and hence the measure will be worse than no remedy. This has already been partially answered. The trap corn is reduced to the minimum in quantity. This makes a maximum crowded condition which induces the maximum cannibalism in the species and, as already explained, actually makes the Boll Worm its own destroyer. On the other hand, if the trap corn were not planted the moths would of necessity deposit on cotton. Here there is plenty of room and each

individual worm would feed and mature independently; hence no conditions exist to induce their preying upon each other and the maximum number of worms attain maturity.

The results of this preventive measure may be concisely stated to be: First, protection of the cotton. Second, the minimum number of Boll Worms reach maturity without additional expense after being trapped. Third, the first and second are both attained without special cost, in that no money outlay is necessary; no additional labor, since the same would be required were the rows cotton instead of corn; at any rate corn enough is produced to pay for the time and labor required. Fourth, beneficial insects are more or less attracted and their attack concentrated to a certain extent upon a single obnoxious insect. Fifth, the planter thus protecting his cotton is certain to succeed, whether his neighbors attempt equally with him to protect theirs or not, for, having fresh corn in good condition in his cotton, visiting moths from adjoining farms will choose to deposit and the resulting worms will ravage the corn to the practical neglect of the cotton.

COW-PEAS.

For attracting or diverting the Boll Worm moth from the cotton this crop ranks next to corn. The essential point to be attained is to plant the peas at such a time that the crop will be in the height of its blooming period during the latter part of August and September. The Boll Worm moth is very fond of sipping the sweets at the base of the developing blooms and very young pods. The peas answer the purpose best it seems if planted in distinct rows adjoining cotton fields. The growth should be rank and dense, so as to induce the moths to make these rows of dense growth their hiding place. From observation it has been often found that where patches of peas in prime condition were met with during August and September the moths were found there in great abundance and to the practical exclusion of them in the adjoining cotton.

In case it is found that the late-planted trap corn will mature rather too early to be of the greatest value, and especially in regions where drought is apt to prematurely ripen corn, it is to be urged that cow-peas be planted between the rows of corn in time to furnish a continuation of the trap through the rest of the season. In any case it would be well to plant the peas as suggested as an additional attraction along with the trap corn. Care must be taken that only a minimum area is planted, in order that, possibly, other remedial agencies can be applied with the least possible expense if found advisable to do so.

POISONED SWEETS.

The only crop upon which there is a probability of practically utilizing poisoned sweets is that of the cow-peas, planted in limited areas as

previously recommended. With a limited number of rows, and these swarming with Boll Worm moths, a tasteful and attractive sweet well poisoned and thoroughly applied is of some value. A great difficulty is met with in that the liquid applied dries after a short time and whatever moths are to be poisoned in this way must feed soon after the application. This process makes a daily application necessary and of course renders the crop as forage entirely useless. The worst feature, however, is that the poisoned sweet, in order to be an effective poison, must be made so strong that one thorough application burns the foliage and checks the growth of the vines to such an extent that from that time the pea-vines become useless as a crop for attracting the moths. Thus the very purpose for which it was planted is suddenly discontinued. If the brood of moths found at this time issued evenly, this might not be so serious an objection, but, since the brood issues very scatteringly, it is desirable to have the trap a continuous one.

Hence it appears that whatever of benefit is attained by the use of this insecticide it is at too great a sacrifice to make the extensive application of it advisable.

Experience has shown that the poisoned liquid must be actually applied to the food-plant in order to be most attractive, and hence most efficient. If placed in pans or plates or on posts, boards, and like objects, a few moths are trapped occasionally. These catches even seem rather accidental, as the great majority are not attracted and, in fact, the liquid offered in any other locality than upon choice food-plants seems really to form no decisive attraction.

PYRETHRUM.

As already intimated, no insecticide can be of practical utility against the Boll Worm. Much work has been done, however, in making decoctions and various extracts of this powder. The principal points considered were those of determining the difference in extractibility of hot and cold decoctions, hot and cold extracts with oils, such as kerosene or head-light oil. These various extracts and decoctions were always made into an emulsion with oil. The emulsions were then diluted and applied in the usual way. There is some difference in the extent of extraction of the insecticidal properties by hot and cold processes, as also the aqueous and oil extracts. The difference by one of the processes is a decided one, though its practical utility upon this particular species is questionable, except in special cases under certain conditions.

LIGHTS.

Numerous and decisive experiments with lamps for trapping Boll Worm moths were made. Some of these were made under the most favorable circumstances. They all proved the absolute folly of this practice among planters. The moth is not attracted much at any stag

of its existence, and whatever insects are captured are on the whole decidedly beneficial. This practice then is a positive injury, in that it systematically destroys beneficial insects without accomplishing any good as a recompense. This measure, so commonly practiced by planters, should, in view of the decided and constant harm attendant upon its use, be unhesitatingly condemned whenever opportunities are presented for doing so.

INSECT DISEASES.

In order that any insect disease should be most efficient and practical, it is necessary that the pest to be infected be gregarious in habit and travel freely enough to intermingle frequently. For the Boll Worm both of these conditions are found directly by opposites, it being solitary in habit and not traveling about as frequently as most species of worms of economic importance do.

Furthermore, feeding on the inside of the portions attacked their chances for infection through natural agencies and communication with diseased worms are proportionately decreased. Even should a Boll Worm become diseased, in the majority of cases it would die in a boll or ear of corn and the deliquescing portions of the body containing the germs would be absorbed by the rotting or fermenting boll. No other worm, therefore, is ever exposed to infection from it. The solitary habits of the Boll Worm in the midst of suitable plants offering a great plenty of food furthermore insures the most healthy and least accidental condition possible. None of the factors, such as excessive numbers, often resulting in a scarcity of food, thereby reducing the vitality of the worm, enter into consideration in the case of the Boll Worm. All or any of these are conditions which greatly favor the propagation, infection, and distribution of diseases. These facts concerning the numbers and food-habits of the Boll Worm make it impossible to accomplish anything in a practical way with this species, even though the diseases in question were highly contagious and efficacious as destructive agencies. The reason, as already stated, consists in the fact that there are certain conditions required in order that contagious diseases can be introduced and disseminated, and those conditions are wanting in this species.

Again, if there were any contagious insect diseases of economic importance prevalent in the cotton belt they would before this time have made evident their efficacy, especially when it is considered how long cotton and other crops have been under cultivation, and which have been so long ravaged by all the various insects, from some of which we might expect the occurrence and spread of disease. There are such diseases found in the cotton region, and they have been found in such localities as to make infection possible under the conditions as above stated. By observation it has been determined that occasionally Boll Worms do die, and apparently from disease. Whether peculiar to the species or due

to infection from other sources need not be stated here, because the important point is that, in either case, the results thus attained naturally are for this species, probably the best possible even by the coöperation of artificial means. This is in reference only to any possible insect diseases already found in the region where the Boll Worm depredates on cotton.

The only hope then would seem to be the introduction of a foreign disease, or at any rate one not already found in the infested regions. This was thought to be the case with the Cabbage Worm disease. This disease, even in localities in the South where it is prevalent, produces no wholesale exterminative destruction of that species. This disease in itself, then, under the local existing circumstances, is not of that virulent kind necessary in most cases for the infection of a new pest in a new locality. (This is only generally speaking, and is not to be understood as meaning that a disease virulent in one species will be equally so in another, or that a disease mild in one pest might not be virulent in another.) Furthermore, the Cabbage Worm disease is already found in a mild form in some portions of the cotton belt; also, a very prevalent disease of the Cabbage Plusia (*Plusia brassicæ*), and which is probably the same as the Cabbage Worm disease. Small patches of cabbage are found here and there at quite frequent intervals throughout most of the cotton plantations, a condition resulting from the system of small negro tenantry prevalent among Southern planters. Thus every opportunity is offered for the spread of the disease in question in case it were highly contagious and of practical economic importance in this connection. In fact it has been found that the Boll Worm is occasionally found to be diseased. From symptoms and other bacteriological evidence it is now quite definitely determined to be identical with the Plusia and Cabbage Worm disease. It is quite probable, therefore, that these diseases are already doing their work as extensively as is possible under the specially peculiar circumstances already mentioned, and which are such as to quite effectually baffle artificial means.

The importance of the work with insect diseases is not to be underestimated, however. The work which it was possible to do simply demonstrates that by mere contagion and transmission no great and wonderful results are to be obtained. Rather in this case the question becomes one of virulence, and not merely susceptibility to infectious diseases. One acquainted with bacteriological methods knows that these two objects can not primarily be accomplished simultaneously in a single investigation; that is to say that the question of the inefficacy as a practical economic measure by the transmission of any contagious disease must be determined first, and then attention is given, if the pest is found susceptible, to those conditions which might increase the virulence of the disease-producing germs in question. The work, therefore, so far as followed out, is thorough and conclusive, but from the

nature of the case only one portion has been completed. What possibilities lie in the way of experimenting purely with the germ in order to attain the necessary virulence actual experiment will have to demonstrate. In addition to giving attention to the virulence of the disease germs, more study should be given the natural conditions in order to determine whether they may be artificially varied so as to be more conducive to the dissemination of disease.

Above all, the subject ought not to be summarily dismissed, since only a limited number of germs could possibly be experimented with. True, the most hopeful ones were experimented with first, but yet it may transpire that other well-known diseases, not yet tried, may be efficient. The work has really been one of elimination of some specific germs by which it was thought certain desirable results could be attained rather than such as to conclusively demonstrate the impracticability of utilizing insect diseases in the province of economic entomology.

INSECTS OF THE SEASON IN IOWA.

By HERBERT OSBORN, *Special Agent.*

LETTER OF SUBMITTAL.

AMES, IOWA, *December 5, 1891.*

SIR: I submit herewith my report on the more important insects of the season in Iowa. The year has been one of unusual prosperity and excellent crops in the State and the ravages of insects have attracted correspondingly little attention. Observations on some other species than those here mentioned are still in a condition too fragmentary to warrant detailed report.

Very respectfully yours,

HERBERT OSBORN.

Dr. C. V. RILEY, *Entomologist,*
Washington, D. C.

The past season has been quite free from any sweeping insect invasion, and, aside from the prominence of plant-lice and their great multiplication upon plums and wheat and the spread of the Clover-seed Midge, there were none to attract special attention or to cause serious alarm. There were of course the ordinary species present in their usual abundance, and there is no doubt that crops were affected in considerable degree; but the loss was not such as to attract unusual attention, and it is of course a matter of regular occurrence for a certain amount of loss to occur in all crops without causing much inquiry from cultivators. In fact, it is the common rule to consider these attacks of little moment, or to believe them too little to be worthy the expenditure of time and money to attempt their prevention. For some crops, and where the cost of application of remedial measures would be large, it is doubtless true, but there are certainly many instances where the expense of applying some remedial agent or the trouble of adopting some method of culture to avoid insect increase would be abundantly repaid.

The White-winged Bibio (*Bibio albipennis*) attracted considerable attention in the spring, appearing in great numbers in many parts of the State, and in a number of cases it was sent in with the statement that it was eating foliage of various plants. The evidence gained, however, did not suffice to establish any case where actual damage was

done to foliage, and we can but think that the flies occurred on plants that had been previously eaten by some other insects and that the work was erroneously attributed to these Bibios when they appeared in such numbers.

Plant-lice were very abundant on almost all kinds of plants, and especially on plum trees did a great deal of damage. The species known as *Aphis prunifolii* was one of the most abundant forms, but other species occurred, and one which was apparently the most common and destructive appears to be referable to *Myzus persicæ.* This is a brown or reddish-brown species, with greenish legs, and it occurs in great abundance on the terminal portions of the twigs and causes very extensive curling and twisting of the leaves, being almost as bad as some gall-forming species in the amount of distortion produced. On this account it is more difficult to destroy with kerosene emulsion than the forms that are less protected, and we found that in some cases the only satisfactory method of reaching them was to dip the worst branches directly into the emulsion and wash them about till all the corners and cavities had been reached. Later in the season the parasitic insects affecting these lice became abundant and their injuries were practically stopped. They can most seriously affect the growth of the fruit as well as the general health of the tree. On a small tree upon which I allowed them to develop for the purpose of watching their progress, they clustered on the stems of the plums, and even on the plums themselves, and the fruit thus infested became much wilted, much of it covered with exuded juices; and even after the lice had been destroyed by parasites failed to recover and make a good growth, some attained only about half size, and were tough and of poorest quality when ripened, while a portion became so withered that they failed to ripen at all. It is evident that the insect should be attended to early in spring, before the lice become numerous and the leaves become curled, as then they can be destroyed very much easier and it will prevent the damage to the fruit.

Two other forms, apparently distinct species and quite different also from *Phorodon humuli,* were observed in small numbers on wild plums, but they have not as yet been referred to any described species.

The Wheat Plant-louse (*Siphonophora avenæ*), which has been abundant in States east of here for a few years past, appeared in abundance in the eastern part of the State this season, especially in the northeastern portion (Jackson and adjoining counties). It seems to have been noticed first only a few weeks before ripening of grain, and for two or three weeks I received a great number of samples. In almost every case, however, the specimens sent were noticed to be in large part affected with parasites, and I could reply that the injury from the lice would probably soon cease. In all cases where I received a second notice from the same place it was to the effect that the parasites had been increasing and that the injury had ceased. The louse is evidently

widely spread. It was seen at Ames in small numbers on oats, but in this case also accompanied by parasites; and while it is probable that wheat and oats may be affected by the louse another year, I think we may depend upon the parasites being sufficiently numerous to prevent serious loss. It would, therefore, not seem advisable to reduce in any degree the planting of wheat or oats or any of the crops that may be affected by this species on account of possible loss from this pest.

The Dogwood Plant-louse, which has been referred to in previous reports, has been observed further and some additional facts secured, but there are still some points of importance to be determined. Eggs of this species and of the Dogwood Aphis (*Aphis cornicola*) were deposited freely on some small dogwood bushes near my office last fall, and I had an opportunity of watching them pretty closely during the spring. The eggs near the ground seemed to pass the winter most perfectly, and for the Schizoneura hatched in fair numbers in spring, a short time before the blossoming of the Dogwood. The insects gathered upon the expanding leaves and also on the blossom buds, and as the latter opened they seemed to gather by preference in the bunches of blossoms clustering upon the stems and at the bases of individual blossoms. Apparently the second or third generation acquired wings, and the Schizoneura then disappeared entirely from the Dogwood. They were not to be found on grasses for some time later, but they would necessarily be scattered widely and difficult to find at first.

During the autumn I received word from a Mr. Bower, of Norway, that his corn had been troubled with plant-lice, and he sent me samples of Setaria infested with Schizoneura, which he said were the same as he had been troubled with on his corn.

Thinking it probable that it was *Aphis maidis* that was affecting the corn, and not the Schizoneura, I requested him to send samples if he could then find them of the lice on the corn roots, and he soon sent me some roots of corn on which were a number of Schizoneuræ resembling in every respect the Schizoneura so common on grass. Some of these were quite evidently acquiring wings, and shortly after I secured from them a winged individual, which agrees closely with *Schizoneura corni*, except that the antennal sensory pits are not so distinctly developed.

As the specimen was mounted while still quite fresh, there is a possibility that the sensory pits had not become as well marked by the rigid chitinous border as in more mature individuals, and while I can not affirm their identity it seems probable that they are the same. If identical with the species affecting the Foxtail, it is evident that there is an important relation between this weed and the corn with which it grows so abundantly. It is certain that we have in the species of Schizoneura here noticed another corn pest that is easily equal to the common corn-root louse in its power to injure this important crop.

The Clover-seed Midge has become a serious pest in many parts of the State, and, while it has been observed before and attention called to

the necessity of preparing for its probable spread here, this year is the first one in which there has been a loss so great as to cause much alarm amongst the farmers. Its most serious ravages have been in the north-eastern part of the State, where clover has recently become a quite important and extensively cultivated crop. In many localities from which I have received reports the loss of the clover seed this year has been quite complete. In some cases it appears that the clover has been quite extensively infested with the Clover Thrips (*Phlœothrips nigra*), the slender red larva of which seems to be by some mistaken for the larva of the Midge. The Midge was treated in Bulletin 13 of the Iowa Experiment Station, illustrated with your figures, and it is hoped that this discussion and the quite general attention it has received from the agricultural press of the State will enable the growers of this valuable crop to adopt measures by which to secure good crops of seed.

Another quite serious pest during the year was the Clover-seed Caterpillar (*Grapholitha interstinctana* Clem.), which appeared in this locality in great abundance and caused the loss of a large percentage of the seed, though, since for the first crop there was no effort to secure a crop of seed, the loss was, of course, not so important. This species has been treated in detail by Mr. Gossard and myself in Bulletin 14 of the Iowa Experiment Station and in an article presented to the Association of Economic Entomologists (published in INSECT LIFE), and it is therefore unnecessary to go into detail regarding it here. It may be stated, however, that it has been determined to be three-brooded here and that it was found that, when the clover was cut and stored for the first crop with the larvæ of the first brood still in the heads, all the larvæ perished, and it is deemed a complete method of destruction for the species to cut and store the clover while still in bloom the first time, provided this is quite general, so that larvæ infesting the scattering clover in fence corners and along roadsides are not developed in abundance to lay eggs for the later broods of the season.

The Flavescent Clover Weevil (*Sitones flavescens*) also occurred in considerable abundance here, and it is probably quite generally distributed through the State, since its habits are such as to attract little attention.

The common species of locusts were abundant and in some localities I learned of considerable damage to clover and other crops.

In a number of trials of the hopperdozer plan of treatment for the Grass Leaf-hoppers (which works effectually also for the young of locusts), it was found that a simple flat sheet of sheet iron covered with coal tar on the upper surface and drawn along by means of cords attached at each end was a most effective method of capturing the jumping species not only of leaf-hoppers, but young locusts and a number of other small insects. A paper giving results of these tests was read at the Washington meeting of the Society for the Promotion of Agricultural Science, and published under joint authorship with Mr. Gossard

in Bulletin 14, Iowa Experiment Station. The most important results may be here stated. In an experiment upon a plat of grass land a portion was treated with the tarred sheet on May 29; the remainder of the plat, or rather a corresponding portion on the opposite side of a narrow roadway, was left untreated. On June 9 a trial by running the tarred sheet over a strip 3 rods in length on each plat, it was determined that by actual count the leaf-hoppers were more than five times as plenty on the plat that had been untreated as on the treated plat. And July 2, when the hay was cut on each plat, the yield from the treated plat was 34 per cent better than that of the untreated plat.

On June 20 the tarred sheet was tried on another part of the lawn, and, "in moving 55 feet with the dozer, the number of leaf-hoppers taken was estimated by counting the insects on three sections of the dozer, each 6 inches long and extending the entire width of the dozer. The counts were 183, 319, and 226, respectively, which averages 243 for each section, or 4,131 on the whole pan. At this rate about 376,000 insects would be caught per acre.

"Another test was made at the same time, dragging the dozer over 66 feet of lawn. This time five sections of 6 inches each were counted off and averaged, instead of three, which resulted in giving 2,805 insects on the dozer, or 213,089 would be taken on an acre."

In previous reports I have given some estimates as to the number of these leaf-hoppers that may occur on an acre of grass land, and it will be seen that these trials not only give confirmatory evidence as to the great numbers of these pests that live in grass, but show that they can be captured successfully by the hopperdozer plan. Since the latter trials were made in hot weather and when most of the insects were winged, it was impossible to capture all of the hoppers, and it is probable that the actual number of hoppers on the land averaged well up to 1,000,000 per acre. By selecting best conditions, it will be possible to capture a larger percentage, and the profit of securing even half of the hoppers in the grass will, I believe, well repay all expense and trouble of treatment.

A very interesting occurrence of the year was the remarkable increase of a parasite (*Apanteles glomeratus*) affecting the common Cabbage-worm (*Pieris rapæ*).

About the 1st of May I received from you some parasites imported from England, but they were already issuing from the cocoons and there had been no cabbages planted at the time in this locality, so that my only hope of getting them established here was to place them on Black Mustard growing wild, and even here I had little hopes of getting them established, as *P. rapæ* had only begun to appear in the imago and there was little possibility of larvæ being ready in time for oviposition of Apanteles. About the 1st of August I was somewhat surprised to have brought to me a number of *rapæ* larvæ with cocoons of a parasite that resembled exactly the Apanteles. When the imagos issued

they proved to be, so far as I could see, identical, and my opinion was confirmed by referring the specimens to your office. The Apanteles had been most abundant in the gardens of a Mr. Gregory, a gardener near Ames, but about 3 miles from where the Apanteles had been introduced, and it seemed almost impossible that they could have become so widely distributed and so abundant in so short a time. I made careful inquiries of Mr. Gregory, and found that the parasite had been first observed by his wife in the fall of 1890, but in small numbers, and at the time supposed to be an injurious species, and all that were observed had been destroyed. During the summer just past, however, she had seen the larvæ issuing from the caterpillars and rightly appreciated their beneficial nature. They became so abundant in Mr. Gregory's garden that he told me they had entirely destroyed the cabbage worms on his place, and they also multiplied extensively in the cabbage patches on the college farm, so that there will probably be very few of the cabbage worms another season and even if they appear in some numbers the parasites should be so thoroughly distributed as to be able to keep them entirely in check.

While this occurrence of the Apanteles by some previous introduction makes it impossible to say with certainty whether any were established as a result of the introduction of last spring (and the probabilities were against a successful issue in this case) there is the strongest proof of the ability of the species to thrive and to successfully reduce the numbers of *Pieris rapæ.* It would be of interest to ascertain the source from which they were introduced, but nothing could be learned of any probable introduction direct from any distant point and it seems most likely that the species has simply spread through its own powers of dispersal from other parts of the country where it has been present. It would seem to be a very easy species to distribute from one point to another, but for the Northern States it would seem more easy to introduce in the latter part of the season, as the imagos issue in spring too early to find *rapæ* larvæ ready for them to oviposit upon. Mr. Gregory informed me that the parasites were noticed issuing from the pupæ as well as from the larvæ.

The Apple Maggot, which reports indicated as common in some sections of the State last year and which it was feared might prove troublesome to our orchardists, has not been heard from the present season, although the apple crop has been a large one. Should it make no further appearance it would seem to strengthen the idea that it does not thrive in this region, perhaps on account of unfavorable soil, a condition that may be viewed with much satisfaction by our fruit-growers.

REPORT OF ENTOMOLOGICAL WORK OF THE SEASON OF 1891.

By F. M. WEBSTER, *Special Agent.*

LETTER OF SUBMITTAL.

COLUMBUS, OHIO, *October 10, 1891.*

SIR: I herewith submit my annual report for the current year. My last report preceding this related to the development of the Hessian Fly, and especially as showing the desirability of late sowing as a means of warding off the fall attack. It seems, however, that where the carrying out of this advice leads to a procrastination in the preparation of the ground it is likely to lead to injurious effects, where wheat is to follow clover. I have, therefore, prepared the accompanying report in order to show the nature of another class of depredators, and how it is, doubtless, possible and practicable to follow out the directions as to late seeding and still avoid contact with this second evil.

Yours very respectfully,

F. M. WEBSTER,
Special Agent.

Dr. C. V. RILEY,
U. S. Entomologist.

INTRODUCTION.

During the fall of 1890, after the rendering of my annual report for that year, I was engaged in the study of various insects, notably those affecting young growing grain. On February 2, 1891, I started on a tour of investigation through Arkansas and Texas, in order to continue work begun by me in 1886, relative to the occurrence and effect of various species of Simulium infesting the streams of the valley of the lower Mississippi, and also to investigate the depredations of the Grape Curculio in northwestern Arkansas. From the 20th of February to the 1st of April I was in Texas engaged in further studies of Simulium and grain insects. A report of the work of this trip has been forwarded you and published in INSECT LIFE. Soon after my return, in accordance with your direction, I visited the farm of Dr. I. W. Chamberlain, at Hudson, Summit County, Ohio, to investigate an occurrence of the Clover Hay-worm. A report of this and further investigation of the species involved has been forwarded to you. Further investigations

into the habits of some destructive species of Tipulidæ were made, and a report, illustrated by drawings, was presented to you for publication.

A report on observations upon many species of Coleoptera has also been prepared and forwarded to you for publication. In pursuance to your instructions, I secured a large number of eggs of *Lachnosterna*, especially of *L. fusca*, *L. gibbosa*, and *L. hirticula*, and, after carefully watching the development of these eggs, placed the larvæ in breeding boxes, and have colonies of larvæ of each of these three species, reared from the egg, and at present thriving nicely in confinement.

On April 23 I received from you a consignment of *Semiotellus nigripes*, and, in accordance with your instructions, placed the larger portion in a wheat field seriously affected by the Hessian Fly, and the smaller portion were placed on fly-infested plants, under a cover of Swiss muslin. Later I received from Prof. Bruner a second consignment, which was promptly forwarded to Prof. Charles E. Thorne, Director of the Ohio Agricultural Experiment Station, who placed them in two fields of wheat near Columbus, Ohio. In regard to the success in introducing these parasites, I am not yet able to report. I did not rear adult *Semiotellus* from those released among grain, under cover, but this is in no way to be construed into a failure to colonize them in the field. When received many had emerged from the flaxseeds, and some of them had perished, and the larger portion of those remaining were placed in the fields. At the time of the release at La Fayette, Ind., the adult Hessian Flies and native parasites were abroad in great numbers. The field where they were placed had been seriously attacked by the fly during the preceding autumn, fully one-half of the wheat plants being affected. That portion of the field where colonization was made has not been molested since, except to remove the crop. Wheat was again sown on the larger portion of this field and also on another adjoining, also in wheat last year, so that at present there are two fields of wheat growing within 20 yards of the spot where the liberation took place. Therefore, while I am unable to say whether or not the parasite has become established, I can say that it has had every opportunity to do so, and a failure in this case would almost prove conclusively the imposibility of colonization. The number of living parasites placed was too small to show immediate results, and, therefore, time must be given for them to multiply before expecting absolute proof of colonization. With regard to those released here I am not so hopeful, as wheat, owing to dry weather, did not germinate quickly after being sown, and, I fear, may have come too late to afford hosts for the *Semiotellus*. Both fields where the parasite was liberated still remain uncultivated.

On July 1 of this year I severed my connection with the experiment station at La Fayette, Ind., and formed a similar connection with the Ohio Agricultural Experiment Station located at this place, a change which was approved by yourself.

Since locating here several destructive insects have demanded atten-

tion. The Wheat Midge, *Diplosis tritici*, appeared in limited numbers and was investigated in accordance with your instructions. A bulletin was issued by me from the station dealing with chronological data in regard to the pest, and a report submitted to yourself relating to this and some other closely allied species.

Many inquiries in regard to the Hessian Fly have been received, and in order to meet a popular wish my report of 1890 to yourself, and appertaining to this species, has been received and adapted to a station bulletin, which was issued in November of the present year. This, I think, will afford the desired information to the farmers of the State and reply to a vast amount of inquiry, which would otherwise have to be answered by letter.

The indications are that several important pests will demand attention next year, and, with your approval, considerable time will be spent in becoming acquainted with the State and the people, with a view of securing assistance from the farmers and affording the same in return. The facilities offered by the station will enable me to push some investigations which I have not been able to do before.

REPORT ON SEVERAL SPECIES OF CRANE-FLIES INFESTING MEADOWS AND PASTURES, AND WHICH MAY ALSO PROVE INJURIOUS TO WHEAT.

Any extended study of the species belonging to this group of insects, the Tipulidæ, is impeded by many obstacles, owing, first, to the great difficulty of securing a proper determination of the species involved, and, second, to the fact that they are among farmers to a considerable extent associated with cutworms, the larvæ being known as cutworms and the adults as "cutworm flies;" so that it is not only a difficult task to indicate the exact insect, but equally so to secure accurate data with respect to its habits in the fields. In England these insects have long ravaged fields of young wheat sown after clover, but in this country such attacks have not often been observed. With the increasing popularity of clover-growing, both for pasture, meadow, seed, and fertilizer, it would appear that we are on the verge of a new era with respect to the effects of these insects in our clover fields; and even now one who watches them carefully and notes the numbers of adults which are often to be observed about our clover fields can not help but suspect that they are working an injury which we either fail to observe, or, observing, attribute the loss occasioned thereby to other causes. So far as grain crops are concerned, the indications are that the American husbandman will have little trouble in preventing serious ravages in his fields. What the future of our clover lands is to be, especially if allowed to remain intact for a number of years, is yet to be seen. Of the species studied, there is not one the ravages of which can not be almost entirely prevented in young wheat by plowing the ground during late August or early September, and there is every reason to believe that if

the fall growth of clover is kept mowed or grazed off during September and October little trouble will likely follow from the depredations of the larvæ the following spring. Some species, notably the ones studied in the Indiana fields in 1888 and 1890, are two brooded, the eggs being deposited in spring and fall, while *Tipula bicornis*, which was reared from the field at Ashland, Ohio, and a species near or identical with *Tipula angustipennis* Loew, are probably single brooded, ovipositing during late September and October only.

TIPULA BICORNIS Loew.

On May 17, 1888, we received the following note from the editors of the *Anderson Herald*:

ANDERSON, IND., *May 16, 1888.*

We send you by today's mail a bottle with some worms which are taking the place of cutworms in our county. We send them to have them named or to find out the name.

THE HERALD COMPANY.

We visited the locality on May 23, but could learn of but one infested field, this being on the farm of Mr. J. C. Beesom, located about 3½ miles from the city of Anderson. This field consisted of 22 acres of underdrained clay loam, with the soil of the depressions darker colored, the surface, however, being nearly level. The field for the two preceding seasons had been devoted to red-clover pasture, but not pastured during the last year after about August 1. After this date there sprung up a rank growth of clover, and, besides, a great number of Rag-weeds (Ambrosia). During March of 1888 the clover had been almost totally killed, the owner thought by the weather. About April 16 Mr. Beesom began to break the field, and then discovered myriads of these larvæ, which were new both to him and his neighbors. At this time, from a square foot of ground he took two hundred of the larvæ, and did not dare to plant his fields from fear of these worms destroying his crop. On May 16 he found them still in the earth in immense numbers, and noticed that a considerable percentage had disappeared—doubtless pupated.

When I visited the field fully 90 per cent were in the pupal stage, their numbers fully confirming Mr. Beesom's statement as to the number of larvæ, the lower and darker colored spots being the worst infested. There were, at the time of my visit, very few adults to be found in the grass along the edges of the field, but in the sod, which was that of Blue Grass, no larvæ or pupæ could be found. Although the two stages were pretty generally distributed over the whole area of the field, they were especially abundant under clods, turf, or half-covered bunches of weeds and other débris. On the level plowed ground the pupæ could be detected by round holes which they occupied in a vertical position. Under the clods this feature was not so noticeable; although in these cases they seemed to favor the edges of their coverts.

The country was originally thickly wooded, but has for a long time been cleared up, except frequent groves, which are usually pastured. The infested field was one cleared by pioneers many years ago.

The advanced stage of development to which the insects had already attained precluded the possibility of thorough study in the field, especially of the larval habits, and hence we were obliged to be content with a few and a good supply of pupæ, with which we returned home.

After the general habit of these insects the pupa occupies a vertical position in the earth, and the adult, just prior to emerging, pushes from one-half to two-thirds of its body above the surface. In this position a large number of pupæ were placed in breeding cages and the result most carefully watched. The first adult, a male, appeared on May 25, and did not burst from the pupa until after the latter had been protruding from the earth for several hours. The pupa case first bursts along the head and prothorax, and the head and shoulders of the adult first appear. Until enough of the body has been delivered to clear the tips of the wings, egress is brought about by muscular extension and contraction of the abdominal segments. After the wings are free, but while still in its vertical position, the imago changes its tactics, and begins to rock gently backward and forward, drawing up the legs slightly at each backward motion, until they are finally withdrawn from the case, and the now nearly emerged insect bends forward with the nearly empty pupa case and crawls forth. In the case of the female, loaded down with her burden of eggs, the assistance of the male is often required to finally extricate her.

On the 26th a large number of adults of both sexes emerged in the breeding cage, followed on the 27th by still greater numbers, the males in the majority; but hardly to the extent indicated by Mr. Beesom in the following letter, received a few days later:

ANDERSON, IND., *May 29, 1888.*

MR. F. M. WEBSTER: According to promise I will give you a history of the worms and fly. On May 26 the flies were very numerous around the fences, multiplying each day until the 29th, when the field was swarming with the "gran'daddy long-legs." On the same day there was some not yet hatched, but not many, and some were just coming out. I watched their habits, and think from appearance there was about one female to one hundred males. The female is full of eggs when hatched; has about three hundred eggs of a jet black color. I saw the male helping the female out of the shell. He would do this by standing upright with the female pushing back and forth. In this case the shell would be half way out of the ground. As soon as he would get her out he would impregnate the eggs. This is about all I can tell you now.

Yours etc.,

J. C. BEESOM.

Soon after emerging, sometimes within a few hours, the female begins her work of oviposition. Three newly emerged females, placed separately in glass tubes, produced respectively 297, 282, and 289 eggs. In confinement, these eggs were thrown off at the rate of from 3 to 10 per minute.

Authorities differ as to the mode of oviposition among the Tipulidæ; and it is not improbable that there may be a difference of method in different species. Curtis opined that the British species oviposited while on the wing, and Miss Ormerod says that *Tipula oleracea* Linn., oviposits in or on the surface of the ground, while Dr. Riley states that he has witnessed the oviposition of an American species, *Tipula trivittata* Say, and the eggs are forced into the ground by means of a double pair of valves, something as in the case of our common locusts.

In the species under consideration, the terminal abdominal segment of the female is much more obtuse than in some other of the American species, ending in a pair of broad, concave valves or plates, whose office appears to consist in holding the eggs in place and assist in directing them to within the reach of a second pair of organs. With the female standing on a horizontal surface, in a natural position, the egg appears to pass down the oviduct with the concave surface downward, but on nearing the terminus of the oviduct the posterior end of the egg is thrown under and forward, thereby bringing the concave side upward, and lying, seemingly, directly under a small liguliform plate which is attached only at its base. The apical portion of this triangular plate appears to fit the concave side of the egg, which is prevented from going too far backward by the anal valves previously mentioned. It is here that the second pair of plates or valves, apparently the most important appendage, is called into play. This is situated just beneath or a little back of the triangular plate, their bases having very nearly a common origin, and is composed of two movable valves, or claspers (whose base is broadened into a thin flap, which, coming upward at the sides, forms a receptacle for the egg) which, when closed together, form a hemispherical cup having almost the exact form of one-half of the epicarp of the hickory nut; and each of the two parts, when opened, as faithfully represent one of the valves of the epicarp. When the egg is in position on the triangular plate these valves are pressed against and about it, inclosing it on all sides, leaving only a portion visible along the apex; and dropping downwards slightly, but gently, the egg is projected forth with a slight snapping sound, seemingly propelled in much the same manner as one would eject the pit from a ripe cherry by pressing it between the thumb and forefinger. Whether the liguliform plate follows the valves in this downward movement, or not, I could not determine, but think such is the case, as the egg is not projected directly backward, but deflects considerably downward. The movements of oviposition are made so quickly that it is exceedingly difficult to observe the exact action of the parts, and therefore I give them as they appeared to me. Further observation may require a slight revision.

I have an idea that the two elevations at the base of the liguliform plate, which is drawn as seen from beneath, may serve to keep the egg from slipping backward and may also assist in pushing it forward. At the base of plate, on the under side, are two loose ap-

pendages fixed at base and middle, forming, as it were, a sort of basal pocket for each of the claspers. The exact use of these I can not understand, but suspect they assist in some manner in holding, or, possibly, propelling the egg, as, in Pachyrrhina, they are reduced to what appears to me to be a mere cushion.

I wish it distinctly understood that I did not witness oviposition, except under artificial environments, and therefore it would not be best to take too much for granted. But, in view of the mechanism of the organs of oviposition, and the manner in which they are called into play, together with the fact that in the breeding cages the eggs were scattered about, without the least indication of a desire to secrete them, it seems at least doubtful about this species ovipositing in the ground, though it must be confessed the organs of oviposition have a strange resemblance to those of migratory locusts.

The egg.—The egg is 0.8^{mm} in length, and from 0.3 to 0.4^{mm} in breadth, elongate-ovoid, strongly concave on one side, of a jet black color and highly polished.*

The larva.—The larva is about 20^{mm} in length, and in maximum diameter is about 3^{mm}; head retractile, small and horny, whitish in color, and spotted with black; antennæ yellowish; body strongly wrinkled, transversely, especially the posterior segments. In the young larvæ there are on most of the segments sparsely placed, stout, curved bristles, but in the mature larvæ these are more frequently missing. The first segment is small, the others increasing to the eighth; thence decreasing to the twelfth. The first seven segments are much smoother, but not as clearly defined as the last five. The terminal segment is very obtuse, and armed above with a row of four stout hooked spines, curved posteriorly, beneath which are two large spiracles, and below each of these is a short, fleshy spine, curved upward. General color, dingy white.

The pupa.—The pupa varies in length from 13^{mm} to 18^{mm}, and in breadth from 3^{mm} to 5^{mm}; head, with eyes, distinct; the antennæ is insecurely attached along the breast, short, eleven-jointed, the last joint strongly constricted at tip; horns prominent, knobbed, curved, moderately distantly separated at base, with an intervening median black ridge; thorax quite prominent, and rotund above; wings extending to anterior margin of first ventral segment; legs extending, usually, to posterior margin of first ventral segment, where they all terminate together, forming a sort of flap, easily detached from the segment and from each other. The abdomen is usually rather strongly depressed, widening from base to third segment, gradually tapering from thence to tip. Excepting the terminal, all of the abdominal segments are provided with a transverse row of short spines on the dorsal surface, and likewise on the ventral surface, with the exception of the first and second, which have, instead, two large and two small spines, one of each placed on either side of the middle. The terminal segment ends with a cluster of closely placed, fleshy pustules, which appear to be more or less retractile. Back and above these are two fleshy spines, eight in number. The lateral margins of the abdomen are wide and thin, armed with a lateral row of spines, two on each segment. General color of pupa, dull, dingy brown.

As clover was seriously injured throughout the West during the winter and spring of 1888, any attempt to estimate the injury occasioned by these worms would, of necessity, be mere guesswork.

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*Eggs very similar to, if not identical with, these were described some years ago by Dr. Riley, to whom they were sent by Prof. S. A. Forbes, he having found them in the stomach of the Catbird in Illinois. (See Am. Ent., vol. III, p. 24.)

That this species is double-brooded there is no reasonable doubt, later observations showing that the eggs of the fall brood are deposited principally during September, the insect wintering over in the larval stage and finishing this stage in early spring, its period of development being a little later than the following species, although the two may be found abundantly at the same season, the Pachyrrhina appearing first and seeming to be well advanced in the work of oviposition by the time this begins to appear in noticeable numbers.

Respecting natural enemies, Mr. Beesom had observed great numbers of crows and "bee birds" hovering about this field almost constantly, and he was quite positive that they were engaged in the destruction of the larvæ. From what has already been stated, it seems probable that the adults are, to some extent at least, destroyed by the Catbird. Of the probable insect enemies, *Pterostichus lucublandus* was particularly abundant, and Mr. Beesom at once pointed them out as the most numerous in the field, and particularly where the larvæ were then congregated. *Harpalus pennsylvanicus*, *H. caliginosus*, and *Pterostichus femoralis* were also present in considerable numbers, as were also the larvæ of some species of Harpalus and Platynus, these larvæ being especially abundant in places where the pupæ of the Tipula were massed.

PACHYRRHINA sp.?

Late in April, 1890, news came to me of the depredations of a new insect pest in fields of young wheat near Farmersburg, Sullivan County, Ind. This time the depredators proved to be the larvæ of a species of Pachyrrina, but whose depredations were very much like the preceding; a visit to the locality on the 26th, and especially to the fields of Mr. T. H. Kendall, revealing the nature of the depredator and effect of its ravages. The insect was at that time most abundant in the pupal stage, these pupæ, after the manner of the Tipulidæ in general, occupying vertical cells in the ground. Larvæ were, however, present in considerable numbers, both in the earth and on the surface, the day being rainy, and not only about the wheat plants, but also about stray clumps of timothy, of which there were a considerable number scattered over the field among the wheat. For reasons which will appear further on, the numbers present in both stages did not correspond at all with the reports of Mr. Kendall, nor with the amount of damage clearly attributable to the pest. The most seriously injured fields were those which had been in clover the previous year.

Of two fields adjoining each other, one sown on oat stubble, the other on clover sod plowed early in October, the latter was damaged fully 50 per cent, while the former had escaped uninjured. Another field a short distance from these, also in clover last year but plowed late in August, was damaged only about 15 per cent. A clover field adjoining the first two had been completely ruined, but this might have been in part due to the winter, although the insect was present in abundance.

A close inspection of the most seriously injured fields showed large areas of grain totally destroyed, while other areas among them were little injured. The plants themselves had not been thrown out by the frost, but were well fixed in the soil. The day was rainy, and many of the dead plants had a green appearance like that of wetted hay, and did not at all resemble those killed by frost or freezing, indicating that they had withered.

Mr. Kendall stated that up to the 1st of February his wheat was in fine condition, but after that time it began to die, and continued to do so rapidly until about the first week in April, since which time the depredations had gradually ceased. Soon after the trouble began he had observed the larvæ in myriads both above and below ground, but they worked below, not cutting off the plants, but apparently wounding them and sucking the juices. In working about just beneath the surface of the ground they raised ridges like those made by moles, but about the size of straws, and the earth immediately about the plants was often worked up as if by ants or earth-worms.

A large number of larvæ and pupæ were secured and taken home, in order that I might be able to study the method of feeding in the former, secure adults, and watch the oviposition of the females, which, I judged, might differ from those previously studied in case they proved to be of a different species. While collecting this material, not only many dead pupæ were noticed, but larvæ also, lying on the surface of the ground, many of which had turned black wholly or in part, after the manner of diseased cabbage-worms. This led to the suspicion that they had been attacked by a fungous disease, which had reduced their number and consequent injury. While all living material was, on my arrival home, placed in a breeding cage and thus kept out of doors, nearly all of the pupæ were destroyed, almost entirely, I believe, by this fungoid enemy, which Dr. J. C. Arthur informs me is undescribed, and for which he proposes the manuscript name *Empusa pachyrrhinæ*. One larva constructed its cell in the earth in the breeding cage and transformed to the pupa, but the next day this pupa worked itself upward out of the cell and was found lying on the surface dead, and covered with spores of Empusa. How much this fungus had to do with the stopping of depredations of the larvæ on the wheat it is, of course, impossible to say, but it must have destroyed a large percentage of the pest.

The first adult appeared in the cage on the 28th, two days after removal from the field. Other adults emerged so very sparingly, and at such long intervals, that no opportunity was offered to secure fertilized eggs or note the ovipositing habits of the females. The first of the only two females reared was nearly dead when a male emerged, and, though fertilized, died without ovipositing, and the male refused to pair a second time, leaving the second female without a mate, she dying before a second male emerged. Two females and four males

were all the adults secured from the material brought home, the others, as I believe, having been destroyed by the Empusa previously mentioned.

The same species was found in abundance in clover fields about Lafayette during the whole of the month of May, eggs being secured on the 28th from a female taken in the field. We have this year reared adults which appeared June 4. About the 10th of August males began to appear again in great abundance, and both sexes were observed on the 15th, and by the 27th they seemed to be in the height of the ovipositing season; but the females stubbornly refused to oviposit in confinement, and it was only by securing a female while laying her eggs in the field that I secured an additional supply, though I saw a female which had been caught in a spider snare depositing her eggs freely. By the 20th of September the species had nearly disappeared, only spent females being seen, though the present season, near Columbus, Ohio, one was observed filled with eggs as late as the 22d. It seems, therefore, that the ovipositing seasons are, as a rule, from about May 1 to June 15 and from about August 10 to September 25, the period covering about six weeks.

The organs of oviposition in this species are very different from those of the preceding, giving to the posterior segment of the females a very different appearance. Instead of the broad valves we have a pair of chitinous forceps while the lower plates are produced with the prolongations vertically flattened, and the base forms an elongate receptacle. The liguliform plate is less robust and partakes more of a cartilaginous than a chitinous nature, its office evidently being in part sustained by the teeth with which the interior basal part of the second pair of plates is provided. The two pair of plates, when not in use, close up and form a slender prolongation of the last abdominal segment. The egg differs from that of the preceding species by being smaller and having five distinct grooves, presumably allowing the teeth of the lower plates to gain a stronger hold on the egg itself, and thus reënforcing the liguliform plate, which, as in the preceding, seems to fit into the concavity of the egg. The manner of oviposition is as follows: The egg, leaving the oviduct, drops into the second or lower pair of claspers and under the small liguliform piece, the concave side upward. Here it seems to be held in place while the upper organ or plate is drawn backward, the lower being at the same time slightly advanced until the two flattened prolongations drop in between the two upper ones, when there is a sharp click and the egg is thrown forth at an angle of probably 40 degrees. As with the preceding species, the rapidity of the movement renders it difficult to observe accurately or to determine the exact source of propulsion. The females of this species utterly refuse to oviposit in confinement, and it is only by capturing them in the fields, after they have probably begun oviposition, that one is able to secure eggs. Even here, however, we have not been able to witness undisturbed oviposition, and therefore not able to observe whether or not they use

the combined organs with which to place the eggs in the earth, as their general contour would indicate might be the case. More especially does this seem possible as the preceding species, whose organs of oviposition do not seem fitted for placing eggs, oviposit freely in the breeding cage. Besides being grooved, the eggs of these Pachyrrhinæ are smaller and less robust than those of *Tipula bicornis.* The number of eggs which the female produces is also uncertain, as I have not been able to secure accurate data on that point.

On May 7, 1891, I received a number of Tipulid larvæ from Mr. D. F. Wise, of Ashland County, Ohio, with the statement that they were present in one of his fields in myriads, and he was afraid to plant corn therein through fear of their destroying his crop. The owner described the infested field as having been devoted to wheat three and two years previously, yielding about 20 bushels per acre; was seeded to clover, and last year a crop of hay was removed. This spring, however, the clover had disappeared and the entire field of 14 acres furnished only feed enough for twenty-two ewes and their lambs. From these larvæ I reared, June 4, a male and female of this species. Mr. Wise wrote me later that he had observed these worms in his clover fields, and had noticed unaccountable injuries thereto for the last nine years, but thought the intruders were ordinary cut-worms. About the first of April, this year, he began tiling his field, and on the following morning found the bottom of the ditch, though covered with water, was swarming with these larvæ, and the fact of their living in water raised the suspicion that they were not true cut-worms. On May 16, nearly six weeks later, he wrote that those larvæ were still living in the ditch.

When I received the larvæ from Mr. Wise they were placed in a large glass with considerable earth and a clover plant, but no drainage. After waiting a considerable time for other adults to emerge from the larvæ, I concluded that the remainder had died, and paid no further attention to the glass in which they had been placed.

TIPULA COSTALIS Say.

Early in July an examination of the earth in the glass mentioned above, now nearly a solid mass, showed several larvæ, and, what was more surprising, they were still alive. During my removal from Lafayette, Ind., to Columbus, Ohio, and the rearrangement of things, this glass accidentally became filled with water, and remained so for nearly two weeks, when, judge of my astonishment on examining the contents, ten larvæ were found alive and completely submerged in the water, one floating about with its posterior upward. The larvæ were at once removed and placed in a flower-pot, in which a fresh clover plant was placed, and this kept watered. Nothing appeared until September 20, when a male emerged, followed on the next day by a female. These were kept together, and, though copulation took place, the female stubbornly refused to oviposit, and died without furnishing me

with a single egg. The same day on which the latter of these two adults emerged, while riding along the road, myriads of both sexes were observed. They were also received from Mr. J. M. Jones, of Dunkirk, Hardin County, who wrote under date of September 19, stating that they had appeared about the 15th and were literally swarming. He also called attention to the popular notion of their originating from cut-worms. All facts taken together indicate that this species is single-brooded, the eggs being deposited during late September and early October. Mr. Wise states that the larvæ of these Crane-flies are most abundant in low, grayish-black soil, and where the ground is the wettest, and that during heavy rains they appear to work nearer the surface of the ground. He also states that to his knowledge they have never injured corn planted in these fields, and the present season has shown no exception.*

From the foregoing it seems that our clover fields are menaced by at least three species of Crane-flies, one of which is known to be, under certain conditions, exceedingly destructive to wheat, while the other two may rest under grave suspicion. In a former report to this Department I clearly showed the desirability of sowing wheat late in the fall—the exact time depending upon the locality—as a protection against the fall attack of the Hessian fly. It seems now that though sowing should be deferred, plowing, in cases where wheat is to follow clover, should be done late in August, or at least before the middle of September, in order to escape injury from the larvæ of Crane-flies.

Besides the enemies of Crane-flies already given, I have observed an ant, *Aphænogaster fulva*, attack and drag away a living female of Pachyrrhina, and in addition to the bird enemies given by Mr. Beesom the following is a list of birds found to have preyed upon these insects in Illinois (see Bull. State Lab. Nat. Hist. Ill., No. 3, pp. 104–135):

Species of bird.	No. of birds examined.	Ratio of food composed of Tipulidæ.
Robin	114	.01
Catbird	70	.05
Wood Thrush	22	.12
Alice Thrush	11	.06
Swainson Thrush	11	.04

* Since the above was written letters have been received from Mr. Wise stating that the corn in the field infested by the larvæ of this species did not yield half a crop. The plants were thrifty until in August, when they suddenly ceased to grow, with the result stated. Roots sent me show unmistakable signs of attacks by insects, such attacks not being made until after the plants had become well rooted, after which a vast number of small roots had been thrown out to replace the larger ones destroyed. While, therefore, it is as yet too much to say that *Tipula costalis* is a corn-destroying insect, there seems a prospect that future study may prove it to be such.—F. M. W.

REPORT UPON THE GYPSY MOTH IN MASSACHUSETTS.

By SAMUEL HENSHAW, *Special Agent.*

LETTER OF SUBMITTAL.

CAMBRIDGE, MASS., *December 7, 1891.*

SIR: I herewith submit my report upon the Gypsy Moth (*Ocneria dispar*) in Massachusetts, undertaken in accordance with your instructions.

Yours truly,

SAM'L HENSHAW.

Prof. C. V. RILEY,
U. S. Entomologist.

This insect, a native of Europe, is mentioned in the American Entomologist for February, 1870 (Vol. II, p. 771), as accidentally introduced into New England (Cf. also Riley's Second Missouri Report, 1870, p. 10). Though noted at that time as "spreading with great rapidity" it was not until November, 1889, when Prof. C. H. Fernald, of the Hatch (Massachusetts) Experiment Station, issued a special bulletin, entitled "A dangerous insect pest in Medford," that the species attracted general attention.

Prof. Fernald's bulletin, aided by notices in the daily press, led to the mention of the insect by Governor Brackett in his message to the State legislature in January, 1890; he said: "A new enemy is at present threatening the agriculture, not only of our State but of the whole country. I refer to the Gypsy Moth (*Ocneria dispar*), a European insect which has recently appeared in the State. They are said to attack almost every variety of tree as well as the farm and garden crops. They are now confined to a very small area in Middlesex County, but have become acclimated and are spreading with great rapidity. If their eradication is to be attempted, immediate measures are of the utmost importance."

A hearing was given by the Committee on Agriculture and an act was passed by the legislature authorizing the appointment by the Governor of a Gypsy Moth Commission to consist of not more than three members.

The following is the act:

[CHAP. 95.]

AN ACT to provide against depredations by the insect known as the *Ocneria dispar* or Gypsy Moth.

Be it enacted, etc., as follows:

SECTION 1. The Governor, by and with the consent of the Council, is hereby authorized to appoint a commission, of not exceeding three suitable and discreet persons, whose duty it shall be to provide and carry into execution all possible and reasonable measures to prevent the spreading and to secure the extermination of the *Ocneria dispar*, or Gypsy Moth, in this Commonwealth; and to this end said Commission shall have full authority to provide itself with all necessary material and appliances and to employ such competent persons as it shall deem needful; and shall also have the right in the execution of the purposes of this act to enter upon the lands of any person.

SEC. 2. The owner of any land so entered upon, who shall suffer damage by such entry and acts done thereon by said Commission, or under its direction, may recover the same of the city or town in which the lands so claimed to have been damaged are situate by action of contract; but any benefits received by such entry and the acts done on such lands in the execution of the purposes of this act shall be determined by the court or jury before whom such action is heard, and the amount thereof shall be applied in reduction of said damages; and the Commonwealth shall refund to said city or town one half of the amount of the damages recovered.

SEC. 3. Said Commission shall have full authority to make from time to time such rules and regulations in furtherance of the purposes of this act as it shall deem needful; which rules and regulation shall be published in one or more newspapers published in the county of Suffolk, and copies of such rules and regulations shall be posted in at least three public places in each city or town in which said *Ocneria dispar* or Gypsy Moth shall be found by such Commission to exist, and a copy thereof shall be filed with the city or town clerk of each city or town. Any person who shall knowingly violate any of the provisions thereof shall be punished for each violation by a fine not exceeding twenty-five dollars.

SEC. 4. Said Commission shall keep a record of its transactions and a full account of all its expenditures, in such form and manner as shall be prescribed by the Governor and Council, and shall also make return thereof to the Governor and Council at such time or times and in such form as shall be directed by the Governor and Council. The expenses incurred under this act shall be paid by the Commonwealth, except claims for damages by the entry upon the lands of any person and acts done thereon by said Commission or by its direction, which shall be paid as provided in section two of this act.

SEC. 5. The Governor and Council shall establish the rate of compensation of the Commissioners appointed under this act, and the Governor may terminate their commissions at his pleasure.

SEC. 6. Any person who shall purposely resist or obstruct said Commissioners or any person or persons under their employ while engaged in the execution of the purposes of this act, shall be punished by a fine not exceeding twenty-five dollars for each offense.

SEC. 7. It shall be unlawful for any person to knowingly bring the insect known as the *Ocneria dispar* or Gypsy Moth, or its nests or eggs, within this Commonwealth; or for any person knowingly to transport said insect or its nests or eggs from any town or city to another town or city within this Commonwealth, except while engaged in and for the purposes of destroying them. Any person who shall offend against the provisions of this section of this act shall be punished by a fine not exceeding two hundred dollars or by imprisonment in the house of correction not exceeding sixty days, or by both said fine and imprisonment.

SEC. 8. To carry out the provisions of this act a sum not exceeding twenty-five thousand dollars may be expended.

SEC. 9. This act shall take effect upon its passage.

This act was approved March 14, 1890, and the Governor named W. W. Rawson, of Arlington; Pearl Martin, of Medford, and J. H. Bradley, of Malden, as the Commissioners; they organized March 22, 1890. The appropriations for the work were authorized in the following act and resolve, approved April 2, 1890, and June 3, 1890:

[CHAP. 157.]

AN ACT making an appropriation for the extermination of the insect known as the *Ocneria dispar* or Gypsy Moth.

SEC. 1. A sum not exceeding twenty-five thousand dollars is hereby appropriated to be paid out of the treasury of the Commonwealth from the ordinary revenue, for the purpose of meeting expenses authorized by chapter ninety-five of the acts of the present year providing against depredations by the insect known as the *Ocneria dispar* or Gypsy Moth.

SEC. 2. This act shall take effect upon its passage.

[CHAP. 66.]

RESOLVE relative to the insect known as the *Ocneria dispar* or Gypsy Moth.

Resolved, That there be allowed and paid out of the treasury of the Commonwealth a sum not exceeding twenty-five thousand dollars, in addition to the twenty-five thousand dollars authorized by chapter ninety-five of the acts of the present year, for the purpose of continuing the work of the Commission appointed under said act in preventing the spreading and securing the extermination of the *Ocneria dispar* or Gypsy Moth in the Commonwealth.

Of this sum of $50,000 only $25,514.31 was expended during the work of the season.

Naturally the first work of the Commission was to determine the limits of the infested region. The only data at hand stated that the Ocneria was confined to an area in the form of an ellipse about a mile and a half long by half a mile wide situated in Medford. It was at once discovered that the Ocneria was abundant in many other localities. By the end of May, 1890, the infested region was stated to cover a district 4 miles wide and 16 miles long.

At the end of their term of service (February 25, 1891), the Commissioners stated that the infested territory was confined to Everett, Malden, Medford, the westerly parts of Chelsea, the northwesterly of Arlington, the easterly edge of Winchester, and a few scattered localities in Somerville, in all an area of about 50 square miles. The district being determined, an inspection of trees, shrubs, fences, etc., followed, all infested being marked with a piece of red flannel. Attention was first given to the masses of eggs and their destruction was pressed energetically until the first days of May, when spraying began. Lighted kerosene torches were used to destroy the egg masses. They were applied to the eggs in the positions in which they were found.

Many acres of brush land were burned over. The work of spraying began May 12 and was practically finished July 23. Mr. C. A. Longley was in charge of the work and the insecticide used was Paris green, one pound in 150 gallons of water. During the season about 2 tons of Paris green were used and 70,000 trees sprayed. The spraying equipment consisted of a cask mounted upon a wagon, a force pump with stirrer, 100 to 200 feet of hose and nozzles. Four men accompanied each

team. A means taken to prevent the spread of the Ocneria was the employment of officers with authority to stop and examine every team, carriage, horse car, or person passing outside the limits of Malden and Medford and to examine the same. Though the utility of this work was doubted from the first it was continued until most of the larvæ had transformed into pupæ. In the fall months the Commission also did some work destroying the egg masses.

On February 25, 1891, Governor Russell, acting under authority of Section 5, Chapter 95, acts of 1890, sent a message to the Legislature and to the Executive Council removing the Commissioners for cause and placing the work in charge of Messrs. W. R. Sessions, N. S. Shaler, and F. H. Appleton. All the new appointees are connected with the State Board of Agriculture and serve gratuitously. See INSECT LIFE, Vol. III, pp. 472–474 for the act passed by the general court in 1891

and for the rules and regulations of the Committee. Early in March the Committee placed the field work in charge of Mr. E. H. Forbush, to whose tireless energy most of the good results are due.

Starting with the information as to the limits of the infested region given by the Commission of 1890 it was soon discovered that the Ocneria was abundant in many places in addition to those reported. It can now be stated to occur in Marblehead, Salem, Swampscott, Lynn, Lynnfield, Reading, Wakefield, Saugus, Revere, Chelsea, Charlestown, Cambridge, Somerville, Watertown, Waltham, Belmont, Arlington-Lexington, Burlington, Woburn, Winchester, Stoneham, Melrose, Malden, Everett, and Medford. There is a great difference in the abundance of the Ocneria in the various localities, and the bulk of the damage has been confined to Everett, Malden, Medford, and Arlington.

The main lines of work this year have not been different from those adopted the preceding year, though in some details there have been changes. The greatest attention has been paid to the destruction of the eggs. It was thought that the method of burning the eggs *in situ* adopted last year was injurious to the trees and that many of the eggs were not only not destroyed but scattered about. Consequently such as were in exposed situations on trees, fences, etc., were cut out and burned.

The danger of scattering the eggs by this method would not seem to be very much less than by burning them in place.

For egg masses that could not be collected and destroyed another method has been employed. This is called blazing, and is applied chiefly to stone walls, trunks of old trees, heaps of stone, etc.

The apparatus used consists of a cyclone nozzle attached to a pole, a brass rod passes through the pole, a line of hose connects the pole with a tank, from which crude oil is pumped. A blaze thus started, a running fire is secured, and it soon penetrates all the cracks and crevices. This seems a useful and effective way of destroying many eggs not readily reached by any ordinary method. The committee and their superintendent place their greatest hope of the extermination of the Ocneria upon the destruction of the eggs; to an impartial observer, however, the probability of the detection of every mass of eggs scattered over an area of 50 square miles seems very small, especially when it is remembered that they are placed in almost every conceivable situation upon the trunks, branches, and even the leaves of trees and shrubs, upon fences, the sides of houses, under stone walls, piazzas, board walks, etc. So far as my observations go the search for the eggs has been carefully done, though I have found masses of the eggs after the inspection of the locality had been completed. Many similar cases have been reported; they should be considered as a criticism of the method rather than an indication that proper care had not been exercised, for as Prof. Fernald says, "it is not at all probable that one will find all the egg masses even with the most careful searching on the trees in a small orchard."

Owing to a lack of time or insufficient force some of the most badly infested districts were not inspected during the spring search.

Early in May the committee turned their attention to destroying the larvæ by spraying with Paris green. After the visit of the United States Entomologist, about the middle of June, a nozzle that would throw a mist spray was obtained, an ordinary garden nozzle having been used up to that time. A tendency to cover too much ground in a given time was noticed, and also much unevenness in the effectiveness of the spraying. It is quite possible, however, that this unevenness due to inexperience was inevitable under the circumstances.

Though this indiscriminate spraying undoubtedly did much good in lessening the ravages of the cankerworms, Orgyia, etc., it certainly in-

creased an already existing strong feeling against the use of Paris green, and many land-owners did all in their power to annul or neutralize the work of the committee.

To prevent the larvæ ascending the trees two methods were used; the one consisting of a band of printer's ink and the other of strips of bagging. While the larvæ were unable to cross the band of ink, its composition was such that it required renewal every few days, and its application left each tree with an ugly girdle and possibly did injury to the trees. Insect lime would have been a desirable substitute. The strips of bagging served as a hiding place for any wandering larvæ, which were collected and destroyed.

The work of inspecting vehicles passing out of the district was discontinued after a trial of about two months; information as to the chief direction of travel from the infested district seems to have been the only result of this work.

Considerable work was done in trimming trees, clearing away and burning rubbish, and in cementing holes in trees, fences, etc. The habits and natural history of the Ocneria as observed here differs somewhat from the same in Europe.

I have no evidence that it is double brooded. The winter is passed in the egg state. There is much irregularity in the hatching of larvæ, they were first observed on April 15, in 1890, and on the 20th of the same month in 1891; they were abundant May 20. In 1891 larvæ hatched as late as June 17 and by the 10th of July young larvæ, fully grown larvæ and all intermediate stages, pupæ and imagos were found. The young larvæ on hatching scatter, feed chiefly during the night, resting during the day upon the leaves, branches, etc. The tendency to wander increases with growth. In confinement they cluster together, eat more continuously and strip the twigs in a more methodical manner than observed in those feeding at large. Pupæ were abundant July 10; this stage usually lasts from twelve to twenty days though several have given imagos after eight and nine days.

The males fly readily but the females are excessively sluggish; even when blown by the wind they have a marvellous faculty of getting to the ground or to the sheltered side of a tree or fence. The greatest distance I have seen one fly was a little short of 6 feet. The moths are not readily attracted by light.

As is well known the Ocneria is a most general feeder. I have found it on Linden (*Tilia*), Horse Chestnut (*Aesculus*), Maple (*Acer*), Pear, Cherry, Plum (*Prunus*), Rose (*Rosa*), Apple (*Pyrus*), Ash (*Fraxinus*), Elm (*Ulmus*), Hickory (*Carya*), Birch (*Betula*), Alder (*Alnus*), Oak (*Quercus*), Beech (*Fagus*), Willow (*Salix*), and Poplar (*Populus*). It has also eaten, in confinement, Virginia Creeper (*Ampelopsis*), Dogwood (*Cornus*), and Fringe-tree (*Chionanthus*). It refused Grape (*Vitis*). Other records include Quince, Apricot, Pomegranate, Hornbeam, Hazelnut, Lime, Norway Spruce, Larch, Fir, Azalea, Myrtle, Corn, Wisteria,

Cabbage, Chestnut, Arbor Vitæ, Yew, Ilex, Pine, Mespilus, Peach, Millet, Plane-tree, Hawthorn, Mulberry, and Strawberry.

An interesting point in connection with their ability to feed on so great a variety of plants is the facility with which they can be changed from one food-plant to another. I have fed a number of larvæ all from a single mass of eggs, the food-plant of every one of which was different, and with others have changed the food-plant every day during their entire larval history. The larvæ of Ocneria are frequently found with the eggs of a Tachinid attached to them. Generally there is but a single egg, though sometimes two, three and four have been observed; they are usually on or near the head. In most of the cases that came under my observations the Ocneria moulted before the eggs of the Tachinid hatched. Two of the Tachinids which pupated August 19, gave imagos September 2. Another fact which must lessen the value of this Tachinid as a destroyer of the Ocneria is a habit the larvæ have of rubbing the head against some hard substance. This was observed several times, and in some cases the eggs though not detached were injured. Although I can not state that *Pimpla pedalis* is parasitic upon the Ocneria it has been very abundant in the infested region this year, and I think it very probable that it will be found among the parasites of the Ocneria.

Doubtless many birds will be found feeding upon the Ocneria. At this time there are but two species, the Yellow-billed Cuckoo and the Black-billed Cuckoo (*Coccyzus americanus* and *C. erythrophthalmus*), that I can name as aiding quite materially in the destruction of the larvæ. Among invertebrates the following can be named: *Cicindela 6-guttata*, *Camponotus herculaneus*, *Sinea diadema*, an undetermined Syrphus, and Chrysopa, *Lithobius forficatus;* also the following spiders: *Epeira strix*, *Steatoda borealis*, *Lycosa* sp., *Drassus* sp., *Agalena nævia*, *Phidippus galathea* (*mystaceus*), *Epiblemum scenicum*, *Marptusa familiaris*, and *Thomixus* sp.

While the original creation of the Commission and the subsequent transfer of the work to the State Board of Agriculture were warranted by the nature of the emergency, it was undoubtedly a mistake to appoint men to look after such important work—work demanding, in the words of the appointing power, "prompt, judicious, and energetic action"—who were already more than occupied with other work. The fact that they were appointed with the distinct understanding that their services should be given gratuitously, while not equivalent to saying that their services would be slight, does indicate that they would be secondary to more important affairs.

And while it is only just to the present committee to state that they have devoted more time to their work than could have been asked or expected, it is interesting to note that one of them is now in favor of at least a per diem compensation, and recently so testified before a legislative committee.

The destruction of the Ocneria being primarily an entomological question, the need of an entomologist acting in constant concert with the committee would seem to be undisputed. That there was no such person employed is proved by the fact that the Committee allowed the most important month for spraying to pass without procuring the most improved apparatus.

The attention drawn to this insect should lead to the passage of a general law against insect and fungus pests. A State officer acting under the direction of the State Board of Agriculture could recommend to farmers and others the means to be used against noxious insects and fungi, and the law should be so framed that penalties could be imposed upon owners who took no precautions after due notice had been given. Some such legislation would soon bring the orchards and shade trees of Massachusetts into a more creditable condition, and the introduction of the Ocneria could be looked upon as a benefit rather than an injury.

REPORT OF APICULTURAL EXPERIMENTS IN 1891.

By A. J. Cook.

LETTER OF SUBMITTAL.

Agricultural College, Mich., *November 15, 1891.*

Sir: I beg leave to submit the following report of experiments in apiculture for the season of 1891. It will be noticed that in this report the plural pronoun has been used, and this is eminently proper, as Mr. John H. Larrabee has not only had charge of the work directly, but has aided very much by offering many excellent suggestions.

Respectfully, yours,

A. J. Cook.

The past season has been very unfavorable for apicultural experiments, not only in Michigan, but throughout the entire country. The secretion of nectar from clover, and indeed from nearly all other honey plants, was very meager indeed. In Michigan the season has been peculiar for drought and cold. The exceptionally cool temperature has been very general throughout the country, while in many sections there has been an excess of rainfall. As the honey production has been very light in nearly all sections, it would seem that the low temperature might be the chief cause of the light honey crop for this season.

SPECIAL PLANTING FOR HONEY.

The experiments of this season have been a continuation of those of the past three years. The aim has been to determine whether it would be profitable or not to plant solely with the view of increasing the acreage of honey plants, and so the production of honey.

As the expense of planting, use of land, and danger of failure to secure a crop are considered, we easily see that we can not hope for a profitable return unless the plants have value besides for honey, are sure to give us honey despite the season, to grow when planted even though drought confronts us, to grow and thrive with but little care after planting, and to hold their own against insects, drought, and all discouragements.

THE CHAPMAN HONEY-PLANT.

As this plant has been very highly extolled, was lauded by a special committee selected to examine it, and has been widely distributed by Government, it was considered a desirable plant with which to experiment.

Quite a large area was planted to this *Echinops sphærocephalus* on two successive years. The soil was clay loam. The ground was fitted as well as for corn, the seeds sown in drills, and cultivated the first season. The plants came well and grew remarkably well. They never blossom until the second season, so there are no returns the first year. This is the first serious objection to them as honey plants. The second summer the plants blossomed full. They were very vigorous and the blossoms very numerous. The bees seemed to visit the flowers very freely. Mr. Th. W. Cowan, a celebrated apiarist of England, said to me some years since regarding this plant: "The bees hang around it persistently, but I could never see that the gain in honey in the hive was ever perceptible." I found the same true here. Actual weighing showed very little gain, nor was our honey crop superior to that of our neighbors with no Echinops within range of their bees. The plants blossom from July 20 to August 20, at a good time and for a long season, if they were of any value.

In the winter we cleaned the seed. Although previously warned, and consequently protected by veils and gloves, the barbed awns sought out our eyes and skin everywhere. The pain caused was intense. All who aided in cleaning the seed were in agony for several days. Even this alone would or should preclude this plant from general use. To my disappointment, these plants seemed to exhaust themselves this first season. The next year there were almost no blossoms, but new plants came up very thickly from seeds scattered the previous autumn. This failure of the plants to afford blossoms the third season from planting I know is not always true, as I have had blossoms for four years from plants on sand. It is probable that when the plants are very luxuriant and are allowed to seed we can only count on a single crop of blossoms. This season, the fourth from planting, we had a rather feeble growth of plants. The grass and weeds fought with the Echinops for the land and succeeded in so far that we secured a very meager quantity of bloom, and apparently no valuable results in our honey crop. Thus the failure to blossom the first year, the failure to secrete any large amount of nectar, the failure in many cases to bloom the third year, and the inability to compete with grass and *other weeds* without expensive aid, makes it certain that if any plants will pay for honey alone this is not one of them.

THE ROCKY MOUNTAIN BEE PLANT.

This plant (*Cleome integrifolia*) has again been tried for the third year. That it is a very superior honey plant and blossoms at just the right

time, all through July and August, is certainly true; but it is not a very pushing plant, and the seeds will not germinate unless exposed to the weather for months. Thus it is necessary to plant in August or September of the previous year if we expect a fair stand of this plant. When this is done, unless the land is very free from grass and weed seed, the latter will get the start, and our Cleome will be choked out. Thus I think we have proved that Cleome is only suitable for planting in waste places, when from its beauty and excellence as a honey plant it rivals even the Sweet Clover.

There seems little doubt but that we should secure much honey from this plant were we to take the necessary pains to secure a full stand of acres of vigorous plants. But this can be done only at large expense, too large to ever pay in actual practice.

RAPE.

Knowing from the study of small plats, that have been grown here for years, that the Rape (*Brassica campestris* var. *colza*) and the mustards seemed especially attractive to the bees, and knowing that the former was regarded very highly by many farmers for pasture, especially for sheep, it was thought advisable this season to sow several acres of ground to this plant. Part of the land was light sand and another part clay loam. As the plant blooms in about four weeks from seeding, we sowed it the middle of June.

We are likely to have a severe drought at this time, and this year was no exception. The seed failed to germinate well, especially on the sand. By the middle of July both fields were in full bloom, yet the bees did not swarm on the flowers, as we had hoped they would, nor did the honey product seem affected by the near presence of the rape. I am not sure that we gained any special advantage from it. If we did it was not perceptible. The weather for nearly all the time was very cool.

I do not believe it will ever pay to sow rape specially for honey. If it is sown for pasture, as recommended in England and Ontario, there will be but little bloom, and so, even in favorable years, the beekeeper would receive but small advantage. If grown for seed there would be a profusion of bloom, and in favorable seasons the honey product would be without doubt greatly augmented.

It is certainly wise for the apiarist to encourage and even urge the planting in his neighborhood of any and every useful honey plant, as Rape, Alsike, Clover, and Buckwheat. Often from unfavorable weather they will not afford nectar, still they may bridge the whole distance between failure and success.

SWEET CLOVER.

Bee-keepers have long known that Sweet Clover (*Melilotus alba*), though often failing to secrete nectar, is still one of our first honey plants. It not only yields in favorable seasons very abundantly, but

the honey from it is very white and excellent. This plant is known as Melilot, Sweet Clover, White Melilotus, and Bokhara Clover. While one or two authorities, Prof. Thorne, of Ohio, and Prof. Tracey, of Mississippi, have stated that it possesses value as a forage plant, the consensus of opinion throughout the country is that this luxuriant plant possesses little value to feed either green or as hay. It has been sown in many parts of the country by beekeepers and others in waste places and along roadsides, and in such locations has frequently added decidedly to the honey product. It is a beautiful plant, with a sweet perfume, and may well replace Ragweed, Mayweed, Smartweed, etc., along our highways.

We sowed several acres of this plant this spring, six on sand and three on clay. The drought came on and the young plants upon the sand withered and died. On the clay the catch was only partially successful, but the plants have stooled and we think will produce a fairly good crop of bloom. It is our purpose to see if it may not be a valuable silage plant. It surely produces abundantly. If it will be appetizing as silage so as to possess value to the farmer then from its double value as a silage plant and a most excellent honey plant it may well be grown by the bee-keeping farmer and may be urged conscientiously by the apiarist upon his neighbor farmer. This plant, like nearly all the clovers, is a biennial, and so we must wait till next year to complete our experiment, when we hope to prove that Melilotus is valuable for silage.

Our conclusions thus far are that special planting for honey will never pay. Unless we can find a plant that will always secrete nectar, and, as seasons of honey failure occur in all countries, we conclude that none such exist, and we certainly can not afford the expense and labor.

We think our experiments warrant this conclusion. That it may and often has paid well to scatter seeds of Sweet Clover in waste places there is no possible doubt. Along the roadside this plant may well replace such utterly worthless and ugly plants as Ragweed—species of Ambrosia, and Mayweed—*Maruta cotula*. The first year's growth and the second till after bloom are very handsome. After bloom the dry ugly stock may be cut, when the undergrowth from the seeds of the present year will make a pleasing border to the road. Cleome may also be planted in all waste places. This has been done with excellent results in Minnesota and Wisconsin. It is a very handsome plant, and like Sweet Clover is easily subdued if not wanted. In case this is desired the seeds should be planted early, as early as August or September, else they will not germinate well the following season.

BEES AS FERTILIZERS.

Spraying fruit trees in early spring to prevent the ravages of various insects is becoming very common. Spraying trees while in bloom is very likely to poison the nectar and destroy the Honey Bee. This has been done in several cases. Not only have the mature bees been poi-

soned, but the brood has also been destroyed. The fact that doubt has been expressed in reference to such poisoning, and the fact that even legislators have expressed disbelief in the value of bees to horticulturists, led to the following experiments:

Bees in cages were given foliage sprayed with sweetened water, and in other precisely similar cages the same sweetened water in which London purple had been mixed in the proportion of 1 pound to 200 gallons of water. The bees in the first cages were in no way affected, while the others were all dead in thirty-six hours, and in many cases in twenty-four hours.

Thus we have positive proof, both in the field and from laboratory experiment, that bees are very susceptible to the poisonous effects of the arsenites, and that to spray fruit trees while in bloom always endangers the lives of all bees that visit the flowers. In the other experiments we desired to learn how important bees were in the work of fertilization and cross-fertilization of plants. Trees examined in May while in bloom showed twenty bees to one of other kinds of insects. On a rather cold day, such as are likely to occur in time of fruit bloom, hundreds of Honey Bees were found at work on the apple bloom, while almost no other insects were to be seen.

In the following experiment the same number of blossoms were counted on each of two adjacent branches on various trees, shrubs, and plants. In each case one lot was marked by a tag giving the date of the experiment, while the other was surrounded by cheese cloth just before the blossoms opened, thus precluding the visits of all insects from this lot, except such very small ones as Thrips, Jassids, etc., which were so small that they would escape notice. After the blossoms withered the covers were removed, and two weeks later examination was made to note the results. The following table gives the results of the this experiment:

Variety.	Date covered.	Date uncovered.	Number of blossoms.	Date examined.	Fruit set.	Fruit set on comparison.	Remarks.
Apple	May 4	May 25	40	June 11	0	15	
Do	May 4	May 19	75	June 11	0	3	
Crab Apple	May 4	May 19	200	June 11	0	3	Affected by the frost.
Apple	May 4	May 19	160	June 11	2	9	
Pear	May 4	May 19	140	June 11	0	7	
Cherry	May 4	May 19	300	June 11	9	119	
Strawberries	May 18	June 16	60	June 22	9	27	
Do	May 18	June 16	212	June 22	80	104	
Do	May 18	June 16	123	June 22	20	36	
Raspberries	May 26	July 6	2 canes	July 6	....	....	As many perfect berries as on canes not covered.
Do	May 30	July 6	184	July 6	93	160	
Do	May 30	July 6	1 cane	July 6	....	....	No difference by count or appearance of fruit.
Red Clover	June 12	July 30	10 heads	July 30	0	191	
White Clover	June 5	July 30	10 heads	July 30	0	541	

In the case of the strawberries boxes covered with cheesecloth were set over the plants. As these stood on the ground, of course insects may

have come up from the earth. Thus a few insects may have gained access to the flowers, as we note that the plants were covered for about a month.

We see that in every case the fruit was greatly lessened, if we except the two cases of raspberries. In several cases, notably those of the clovers, no fruit or seeds were secured in the covered specimens. The strawberries seem less affected than any other of the plants, except the two cases of the raspberries. This may be owing, as suggested above, to the presence of insects that could come up from the earth beneath the plants. Perhaps strawberries, when the blossoms contain both stamens and pistils, are less dependent on insects than many other fruits. The two cases of raspberries are curious. We can not explain them. The fact is very apparent that fruit-growers are nearly or quite as much interested in the presence of bees as are the bee-keepers. Pomologists then may well join hands with the apiarists in demanding and securing a law making it a grave misdemeanor to spray fruit trees while they are in bloom.

EXPERIMENTS IN BREEDING.

That bees, like all other organisms, are greatly subject to variation is known to every bee-keeper. That they can be greatly improved by careful selection is equally well understood by all observant queen-breeders. The mating habits of bees are such as to make experimentation in breeding difficult, but the obstacles are not unsurmountable. We are working to overcome them and to develop a superior strain of bees by judicious crossing and selection. This is slow work, and we can hope for decided results only after a long period.

Our stock is from Syrian and Carniolan, and, as the former predominates, we have this season bred very largely from Carniolan. Several of the most prolific queens are selected, and it is our purpose to use the ones from these that winter the best the coming winter for breeding next season. We shall try to test the Punic bees and, if they show superiority, introduce some of this blood.

Besides the above, several other experiments of a miscellaneous character have been conducted which are of more or less interest.

CONSUMPTION OF HONEY IN THE SECRETION OF WAX.

This experiment was performed that we might determine how much honey it requires to enable the bees to secrete 1 pound of wax. Three colonies were taken, which we will designate as No. 1, No. 2, and No. 3, the bees of which weighed $6\frac{1}{4}$, $8\frac{1}{4}$, and $5\frac{1}{4}$ pounds, respectively. No. 1 was given a virgin queen and no comb or honey. No. 2 was given a virgin queen and empty combs. No. 3 was given a laying queen and empty combs. A vigorous colony on scales during the experiment gained $4\frac{1}{2}$ pounds. The bees did not fly from these hives as vigorously as from hives not in the experiment. The feeding doubtless had some-

thing to do with this. No. 3 seemed to gather more honey and to be in a more normal condition than Nos. 1 and 2. No. 3 had a full frame of brood nearly ready to seal at the expiration of the experiment. August 15, 28 per cent of the bees in No. 1 had wax scales, while none of No. 2 that were examined had wax scales. The experiment commenced August 11. The bees of each colony were fed 21 pounds of honey. The experiment lasted ten days.

	No. 1.	No. 2.	No. 3.
	Pounds.	*Pounds.*	*Pounds.*
Weight of bees August 11	6¼	8¼	5¼
Total weight August 11, 7 p. m	35	43	40¾
Total weight August 22, 7 a. m	46	62	61⅛
Gain in weight in ten days	11	19	20⅜
Total amount of feed given	21	21	21
Weight of honey extracted August 22	9	16⅛	18
Loss in honey fed	12	4⅛	3
Gain in weight in ten days	11	19	20¾
Wax secreted by No. 1	*11¼	....	....
Pollen in combs at end	⅛	1⅛	†4
Total weight removed at close	10¼	18	22
Apparent deficiency due to scales	¾	1	1¼
Gain in weight of No. 2 over No. 1 .... 8 pounds	....	....	....

* Ounces. † Weight of young brood and pollen.

11¼ : 8 = 16 : x, or about 11 pounds honey to 1 pound of wax.

This experiment gives 11 pounds of honey as the amount necessary to secrete 1 pound of wax. Huber decided, as the result of careful experimentation, upon 20 pounds as the amount, while Viallon and Hasty concluded that the amount was less even than we have found in the above. Of course, in such experiments there will be errors, as from the conditions the colony is not kept in an absolutely normal condition. No brood-rearing should be allowed, and so virgin queens were given to colonies. Whether the bees work with less vigor physically or physiologically when a laying queen is replaced by a virgin, I can not say.

We thought over the experiment a long time and concluded on the above as the nearest approach to the normal of any plan we could decide upon.

The results from colony No. 3, which was normal, show that the error was not great. A repetition will add correctness to the experiment. We shall hope to repeat it another year. We believe the results are not very wide of the truth in actually normal conditions.

DO WORKER BEES FEED THE DRONES?

Several times in the past we have tried experiments to determine whether the worker bees fed the drones, as they do the queen and larvæ, the albuminous portion of their food. We know that drones are great honey-consumers. It is reasonable to suppose that they are equally great consumers of the albuminous food or bee bread. There is little or no doubt that the upper head glands of the younger worker bees secrete the liquid that digests the pollen. These glands are large and turgid in the young or nurse bees, shrunken and inactive in

old worker bees, and absent in the drones and queens. From analogy, then, we would reason that the queen, drones, and older workers—the bees that do the outside work—as well as the larvæ, are fed the digested pollen, which is rich nitrogenous food. If this is true, and there can be no longer any doubt, then we have double reasons to reduce the number of drones in the apiary, to save honey and pollen and also the energy of the nurse bees.

To prove this point we repeated the previous experiments of caging drones in the hive behind a single wire gauze, a double wire gauze, the space between being more than 0.26 of an inch, which is the maximum length of the worker's tongue, and a perforated zinc cage. Honey was placed in each cage in such a manner as not to daub any bees. In the first kind of cage the bees could reach the drones through the single gauze, though at some inconvenience, so as to feed them the digested food. In the second cages this would be impossible and the drones could only get honey for food. In the third cages the drones were confined, but could be and were freely visited by the worker bees, as the workers could pass freely through the zinc, which the drones could not do. In the single wire-cloth cages the drones appeared somewhat neglected after several days. They lived from four to seven days, while in the cages with double wire cloth none lived over three days, and they generally died inside of forty-eight hours. Those confined in cages covered with perforated zinc lived for over two weeks and would probably have lived much longer.

These experiments agree very closely with those previously tried.

THE CONDUCTIVITY OF WAX.

It is a common practice among bee-keepers to confine the bees in winter to a portion of the hive, thus to economize heat and the better to preserve the health and vigor of the bees. Some experiments by Prof. Gaston Bonnier, of Paris, France, seem to show that the combs are as good a protection as is a division board, especially if fastened to close-fitting frames, or, as in nature, to the side of the hive. To test this matter we used a common division board, a close-fitting empty comb, and a close-fitting comb full of honey These were used successively to confine the bees to one part of the hive and leave a vacant space on the other side. A thermometer was suspended in this empty space and the temperature observed several times daily, and estimates made with reference to the outside temperature. The averages showed no difference with respect to the division board and the empty comb, but did show a slight difference in favor of the comb full of honey. We then used an empty hive, dividing it into three compartments by means of a division board of wood and of empty comb, and again by the use of the wooden board and a full comb of honey, the combs being made equally tight-fitting with the wooden division board. A small lamp was placed in the middle apartment and thermometers in the other

two. The hive was placed in the cellar where the thermometer marked a temperature of 58° F. The temperature in the compartment of the hive with the lamp was 110° F. As between the board and empty comb there was no difference in the temperature in the outer compartments, while with the comb of honey the temperature was 4½ degrees cooler beyond the division, showing this to be a poorer conductor of heat and a better protection for the bees than either the board or empty comb.

Thus we see that for winter protection special division boards are unnecessary if we but use close-fitting frames of comb or make such frames close fitting in the winter time. It is also apparent that combs full of honey are better as nonconductors than are empty combs. Thus in nature bees are well fortified against the cold of winter, as they are combs walled in on each side by several full combs, which are fastened to the side of the receptacle. We also see that close-fitting frames or else frames with wide or close-fitting top and end bars are better to protect the bees than are the common Langstroth frames. It is easy to see from the above why box hives and hives with close-fitting frames, like the Heddon, are well arranged to secure success in wintering.

CELLAR VS. OUTDOOR WINTERING.

In the more northern latitudes of the United States bees winter better as a general thing and consume less honey in the cellar than on the summer stands, even though packed or kept in chaff hives. The last winter was an exception. Our bees in chaff hives wintered out of doors consumed less honey apparently and were certainly in better condition in the spring than were those wintered in the cellar. If we could be sure of such mild winters as the last two have been, cellars for wintering would certainly go out of use. Hence it is to be feared that many bee-keepers will become confident, forgetting the cold and disastrous winters of the past, and soon there may come a return of the severe cold and the mortality among the bees will be as terribly disastrous as in the worst winters of the past. It is well to prepare for war in time of peace. The wise bee-keeper will arrange each autumn for a severe winter. Then he will be safe in any event.

PACKING ABOUT THE HIVES IN SPRING.

We have proved for the past two or three springs prior to that of 1891 that to pack closely about the hives with excelsior or other poor conductors, confining the same by a large, well-covered case set around the hive, has paid exceedingly well for the expense of the case and the labor of adjusting it and the packing. The past spring we could see no such advantage. The unprotected colonies gained as rapidly and were as strong in May as were those in the hives that were protected. The explanation is not far to seek. The last spring was very mild and bees

suffered very little in any kind of hive. Usually we have many very cold bleak days in April and early May; then protection pays exceedingly well. The principle is a good one, "It pays to protect." Occasionally we have a spring like that of 1891, when it is unnecessary, but we should conduct our business for the general, not the exceptional.

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 27.

REPORTS

ON THE

DAMAGE BY DESTRUCTIVE LOCUSTS

DURING

THE SEASON OF 1891.

MADE UNDER THE DIRECTION OF THE ENTOMOLOGIST.

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CONTENTS.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 19, 1892.

SIR: I have the honor to transmit, for publication as Bulletin No. 27 of this Division, the following reports by three of the field agents of the Division on the damage done by destructive locusts during the season of 1891.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

DAMAGE BY DESTRUCTIVE LOCUSTS.

INTRODUCTION.

The season of 1891 was marked by widespread alarm felt at the presence in force of several species of destructive locusts in different parts of the country, and particularly in the Western States. A general summary of these incursions was given in my annual report for 1891, and in this bulletin are brought together the detailed reports of the agents who were sent into the field and who carefully examined the country from which locusts were reported.

Mr. Bruner visited portions of Colorado, Wyoming, the Dakotas, Minnesota, Montana, Idaho, and Utah, and also made a short trip into Manitoba; Mr. Coquillett confined his investigations to the State of California, while Professor Osborn visited the State of Kansas only.

In addition to the localities reported upon in this bulletin Mr. Banks visited Texas and New Mexico, but as his report was negative in character it need not be printed here. Professor Osborn's report has previously been printed in INSECT LIFE, Volume IV, pp. 49 to 56. It will be noticed that Mr. Bruner, in speaking of the species which I have always placed in the genus Caloptenus, refers to them under the genus Melanoplus. The question as to the value of Melanoplus as a genus is discussed in the first report of the U. S. Entomological Commission, and I prefer to hold to the older name. It will suffice, however, for the reader of this bulletin to know that the name Melanoplus as used by Mr. Bruner is synonymous with Caloptenus as used by me.

C. V. R.

REPORT ON DESTRUCTIVE LOCUSTS.

By Lawrence Bruner, *Special Agent.*

LETTER OF SUBMITTAL.

Lincoln, Nebr., *October 3, 1891.*

Sir: I beg to submit herewith a report of my observations on the destructive locusts of the country during the current year, a work which has engaged, as you already know, the greater portion of my time during the past summer. While occupied with these investigations portions of Colorado, Wyoming, the Dakotas, Minnesota, Montana, Idaho, and Utah, along with the Red River Valley of Manitoba, were visited by me. In addition to the regions personally examined, I am also enabled to include reports on other districts based upon reports and specimens obtained from friends who themselves had examined into the conditions of these affairs. It will not seem surprising, therefore, if the greater portion of my report relates to this particular group of insects. Since there have been a number of species of these destructive locusts concerned in the injuries inflicted in various portions of the country during the season, I have thought it best not only to mention all of these, but also to include such others as have been recorded as pests during former years, as well as those that are liable in the future to become injurious over local areas. This report can then serve as a sort of reference hereafter for those wishing to study the injurious insects of this class found in America north of Mexico.

It is but just here to acknowledge the aid which I have received from various railroad companies that took sufficient interest in the locust question to grant it, in the shape of transportation by which I was enabled to visit many regions that would not otherwise have been reached. I would also extend my thanks to all those persons who have aided me in any manner whatsoever during the summer's work among the destructive locusts.

The regions visited by myself and other agents of the Division early in the season, as well as those examined by Messrs. Snow and Popenoe, of Kansas, have been reported upon heretofore; hence will not be treated at length here. The district comprised in North Dakota and Minnesota, over which the true Migratory or Rocky Mountain Locust was more or less abundant, has been carefully studied during the year by Prof. C. B. Waldron in the former and Prof. Otto Lugger in the latter State. The reports of these gentlemen are appended hereto.

Very respectfully yours,

Lawrence Bruner.

Prof. C. V. Riley,
U. S. Entomologist.

About the middle of June reports of damage by grasshoppers or locusts began to make their appearance in the papers of the country at large, and especially were such reports of frequent occurrence and of an alarming nature in the region where the Rocky Mountain locust ravaged the country some years ago. Nor were these reports purely rumor, for it was definitely known to entomologists and others that numbers of these insects had hatched in various parts of the country and were at this time devouring the vegetation at an alarming rate. The past few years had also been very favorable to their increase, while considerable injury to crops had actually been done by these insects during last year. In Colorado railroad trains had been stopped by the insects which gathered upon the rails and were crushed by the heavy wheels of the locomotives. From Idaho and California came reports of grasshopper swarms, and in portions of Minnesota and North Dakota these insects were known to occur in numbers too great for the settlers to be troubled with visions of overflowing granaries. Accordingly, quite early in July the Secretary of Agriculture decided upon a general tour of inspection by specialists in insect study, who were to work under the direction of Prof. C. V. Riley, the United States Entomologist. Several field agents located in different parts of the Union were immediately instructed to examine into the reports emanating from adjacent localities, and to report the results of such investigations promptly.

Having been more or less constantly engaged in the special study of this particular group of insects for the past ten or eleven years, the writer was instructed to make a general tour of inspection over the region known as the range of the Rocky Mountain or Migratory Locust. During the time occupied in carrying out these instructions portions of Colorado, Wyoming, Montana, North Dakota, Minnesota, Manitoba, Idaho, and Utah were traversed. The following reports will give some idea of the results of these various regions visited:

THE LOCUST PEST IN COLORADO.

The first locality which I visited for the purpose of studying these destructive locusts was located in eastern Colorado upon the plains in the vicinity of the town of Akron, on the line of the Burlington and Missouri River Railroad. Here it was found that a large, long-winged locust, which is known scientifically by the name of *Dissosteira longipennis* Thos., was the culprit, and that it was really destroying the grasses on the prairies over an area of fully 400 square miles of territory. A little investigation showed it to be the same species that was present farther to the southward, and that had been the cause of the newspaper reports which filled the columns of the dailies at the time. By driving northward from Akron across the country to the Platte River, other small detached swarms of the same locust were encountered, and judging from such reports as were obtainable at Sterling,

this insect also occurred in destructive numbers in several limited localities of southeastern Wyoming.

At about the same time that I was investigating the northern border of the region occupied by the Long-winged Locust, Messrs. Snow and Popenoe, of Kansas, were studying it along its southern limits, where they found the insect in even much greater numbers than I did along its northern limits of abundance. As those gentlemen have made a much more thorough investigation of the pest than I have, and have written a rather full report of the results of their labors, the readers are referred to that paper if they desire to obtain the full particulars.

The description, habits, distribution, and life-history of this species will be given further on in this report, in connection with like particulars in reference to other species of these destructive insects which occur in North America north of the Mexican boundary.

THE LOCUST PEST IN THE RED RIVER VALLEY OF NORTH DAKOTA, MINNESOTA, AND MANITOBA.

After returning to Lincoln from this Colorado trip, the Red River Valley of North Dakota, Minnesota, and Manitoba was visited. In this latter region it was reported that the genuine Rocky Mountain Locust (*Melanoplus spretus*) was doing some injury to grain. Upon arriving at St. Anthony Park, where I expected to find the Entomologist of the Minnesota Experiment Station, it was found that that gentleman was away from home among the grasshoppers in the northern part of his State. The next halt was made at Fargo, N. Dak., where my letter of instructions suggested that I had better stop and confer with the officials of the experiment station located here, since they were more apt to be familiar with the locust question so far as their State was concerned than would anyone else. Here also I found that most of the station workers were away from home engaged in active work against the locust pest.

By lingering in the vicinity for a few days, and occupying my time in making collections of such species of locusts as were to be found about the college, I was enabled to leave at least twenty species of authentically labeled specimens with the authorities when they returned a few days later. Afterwards a number of infested localities were visited in company with Prof. C. B. Waldron, who had chief charge of the locust work in this State. These short journeys over the region sufficed to show conclusively that not only was the true Migratory Locust present, but also three other species, all engaged in the injuries to crops in the region under consideration. Here then, in the Red River Valley and for some distance back into the "hills" to the westward, were four distinct species of locusts present in unusually large numbers, while, in addition to these, a number of other species were by no means rare. A journey as far north as Winnipeg, in the province of Manitoba, showed that this region of undue increase among these various locusts also extended into that country for some miles be-

yond the point reached. Not having the authority to proceed, I was unable to determine the exact boundary of this region; but from what I was able to learn through inquiry among the intelligent inhabitants, it was surmised that at least one-half of the province was to be included within that boundary. Of course I do not wish to be understood that every portion of the territory thus included was covered by the pest, for such was not the case. The hoppers occurred in spots in Manitoba just as they did in Minnesota and North Dakota. I found that this region contained the following species of locusts in hurtful numbers: the Rocky Mountain or true Migratory (*Melanoplus spretus*), the Lesser Migratory (*Melanoplus atlanis*), the Two-striped Locust (*Melanoplus bivittatus*), and the Pellucid Locust (*Camnula pellucida*).

Further inquiry resulted in showing that the Rocky Mountain species had entered North Dakota during the previous fall from the northwest, dropping into the State at a point just east of the Turtle Mountains, and leaving the first batch of eggs near the town of Cando in Tower County. From here they evidently passed eastward and a little to the south, leaving eggs at various points along the route wherever the conditions were favorable.

It is quite probable that these locusts which entered the country last fall were those that had hatched in spring in the vicinity of Regina and disappeared from that region in a southeasterly direction after becoming fledged. Should this be the case, there are now no other swarms of this particular locust in the United States and British America that we know of, nor does the species appear to be even common in other localities; hence the importance of extra efforts on the part of all interested parties at this particular time to stamp out the pest where it occurs at present. We can easily afford to be without it, for, as the succeeding pages will show, we have plenty of other locusts that are apt to occupy our attention during almost any year in the future. That any of these destructive locusts can be successfully fought and their injuries prevented has been pretty well demonstrated time and again. At no time, however, has this been so plainly shown as during the past spring and summer in this very region in question. This comparative ease with which the insect was handled here is chiefly due to its habit of egg-laying varying somewhat in the Red River Valley from what it is known to be in other parts of the country where it has been studied.

The attached reports of Messrs. Lugger and Waldron, who have been in the region and who had under their direction nearly all of the warfare already mentioned, will best serve to show the *modus operandi* followed and the results secured. Careful estimates have been made as to the actual benefits to be derived from fighting these destructive grasshoppers, and the figures obtained are really surprising. It is supposed that at least calculation 20,000 acres of wheat alone were saved which otherwise would have been destroyed by the locusts that

were killed before and after hatching. This wheat, at 30 bushels to the acre, an average yield for the twelve counties where the locust plague occurred, would be worth about $400,000. The actual outlay in money by the authorities, State and county, for machinery and oil could not have been more than $1 for each $50 saved. We were told that in the two States together there were over 200 "hopper-dozers" at work collecting and destroying the locusts. These machines were kept going for fully two weeks, some of them longer, and each machine caught from 4 to 11 bushels of the locusts per day. It is supposed that fully as many as 8,000 to 10,000 bushels were thus destroyed, many of them being quite small and hence counted for more. At any rate, the destruction was great. An equal number were destroyed by plowing the eggs under prior to their hatching. These figures represent an actual present saving; but what shall we say about the probable future saving to the settlers of these two States and of those adjoining, had none of this work of destruction been carried on? With favoring conditions in climate and surroundings nearly all of our various species are capable of increasing at the ratio of fifty-fold; *i. e.*, each female will lay upwards of 100 eggs. About one-half of the young hatched from these eggs will be males and the other half females. Therefore, if twelve counties are overrun with these insects this year, and they all live to deposit eggs, with all favoring circumstances the result will be sufficient hoppers by the following year to overrun fifty times twelve counties, or six hundred counties, a matter too formidable to think of.

Since I have already reported to you the results of this trip through the Red River Valley, and alse spoken of it at the Washington meeting of the Association of Economic Entomologists, I will not enter farther into details here. Suffice it to say, that after going over the regions already indicated, I went west over the line of the Great Northern Railroad to Helena, Mont., stopping off at convenient points along the road. At these places inquiries were made among the settlers concerning locust abundance, besides going out into the country and examining for myself to make doubly sure that there were no migratory locusts in the entire country west of Devil's Lake in North Dakota. Only at several points in the mountains of Montana did I find these insects at all abundant, and there only over very limited areas where the *Camnula pellucida* occurred in the valleys, in hay fields.

PROF. WALDRON'S REPORT.

FARGO, N. DAK., *Aug. 6, 1891.*

DEAR SIR: In compliance with your request, I submit the following report concerning the recent appearance of grasshoppers in North Dakota.

The first report of grasshoppers came from Orr, a station in the northern part of Grand Forks County. The report was received July * 25, and on July 26 I went to the infested region and found a considerable number of grasshoppers, the oldest of which had been hatched two or three weeks before, while new ones were appearing

*This must be a mistake, and I think should read May 25 instead.—L. B.

constantly. The two prevailing species were the *Caloptenus spretus* and the *Caloptenus atlanis*. The former species was the most numerous, the ratio being about 4 to 1. Other species existed, but as they were found but sparingly no attempt was made to enumerate them.

As was to be supposed, the hatching was confined entirely to the stubble fields. From these the young insects moved forward onto the adjacent wheat fields, and at the time of my first visit a narrow strip of grain along a few of the fields had been destroyed. The usual methods of extermination were resorted to, *i. e.*, the plowing of the adjacent stubble fields and the use of hopper-dozers along the edges of the infested fields.

The Great Northern Railway immediately plowed all of its lands in which the grasshoppers were hatching, and, so far as it was possible, most of the farmers did the same. The beneficial effect of the plowing was very marked even after the process of hatching was well advanced.

The work of the coal-tar and kerosene hopper-dozers was also very effective, each pan catching from 5 to 8 bushels per day. The canvas traps, such as were reported as giving more or less satisfactory results elsewhere, were abandoned after the first one or two trials. When canvas traps are used the grasshoppers have to be caught twice, and the second operation—that of securing them after they have jumped into the bag—is the more difficult one; so difficult, in fact, as to border on the impossible.

While working at Orr reports came in from the adjoining regions, showing that the infested region reached as far north as the center of Walsh County, nearly as far south as Larimore, and occupied a region some 10 miles wide. The grasshoppers did not cover the entire region, but were found in patches here and there, more noticeably in the vicinity of Park River, Conway, and Inkster, with a few at McCanna and Niagara. They were also found through the central part of Nelson County, though not in destructive numbers.

Grasshoppers were also found to some extent in the western part of Ramsey County, at a place called Church's Ferry, and north from there 18 miles, at Cando. In all of the places mentioned the Rocky Mountain Locust was the prevailing kind. A few of this species, associated with many others, chiefly the *Caloptenus bivittatus*, were found at Clifford, in the western part of Trail County. The Rocky Mountain Locust was also reported from the central part of Ransom County, but as they were few in number the locality was not visited. The work of extermination was carried on in all parts of the State in which the grasshoppers appeared in sufficient numbers. While the damage to this year's crop would not have been great in any event, yet the warfare in many localities has no doubt resulted in a larger crop than would otherwise have been harvested.

Our chief concern is for the coming year. I shall stay in the infested localities for the remainder of the season, carefully noting in what regions, if any, the eggs are laid, so that we may carry on the work of future extermination intelligently and thoroughly.

C. B. WALDRON.

MR. LAWRENCE BRUNER,
Lincoln, Nebr.

I add still further matter in reference to this outbreak of locusts in North Dakota in the shape of a special bulletin, which was issued from the Agricultural Experiment Station of that State early in July. This bulletin was prepared conjointly by the Director, Dr. H. E. Stockbridge, and Prof. C. B. Waldron, whose report is already given. This special bulletin is not large, hence will be copied in full.

INTRODUCTION.

(By H. E. Stockbridge.)

On June 19 the Director of the North Dakota Experiment Station received a telegram from Superintendent Jenks, of the Dakota division of the Great Northern Railroad, dated Larimore, announcing the presence of grasshoppers in overwhelming numbers in the vicinity of Orr, Grand Forks County, and requesting assistance and advice in the premises. Professor Waldron, of the station staff, under instructions, left for the scene of the outbreak on the first train leaving Fargo after the announcement was received, and June 20 returned with specimens of the locusts and full particulars concerning the presence, numbers, and amount of devastation wrought, gathered by personal inspection in the field. After further consultation, Professor Waldron immediately returned to Orr, with full instructions and authority to take any steps or action necessary and incur any legitimate expense required for the suppression of the outbreak and extermination of the pest coming properly within the sphere or jurisdiction of the station.

Meanwhile communications had been received from the Commissioner of Agriculture, the Commissioners of Grand Forks County, and several interviews had been held with the Governor of the State looking toward control of conditions and prevention of ravage.

On June 25 the increased presence of the pest and its extension to other localities seemed to demand more stringent measures for suppression, and after a thorough inspection of the infected localities in Grand Forks County, and a consultation, by request, with the township commissioners of the infected townships, it was decided that a more extended use of the hopper-dozer and the plowing of large areas of stubble must be immediately instituted. The use of the dozer was easily accomplished. Twelve of these implements were immediately ordered and put to their work of execution, while a further and large shipment of coal tar was ordered by telegraph. The land-owners in the interested localities seemed to recognize the emergency, and manifested a willingness to do everything in their power toward exterminating the enemy. A great difficulty, however, lay in the impossibility of plowing with pasture-fed horses, and the impossibility, in many cases, of procuring grain or feed on individual responsibility, while the ownership of stubble by non-residents was a further obstacle to the immediate plowing of such land, and thus exterminating their grasshopper denizens. On returning to Grand Forks the Governor of the State, the resident county commissioner, Commissioner of Agriculture Helgesen, Professor Waldron, and the director of the station immediately held an interview, in which the exigencies of the occasion were fully discussed and further measures of control instituted. Feed was immediately shipped to the infested localities on the responsibility of the county commissioners. The general authority of the State in the premises, so far as active measures were concerned, was placed in the hands of the Commissioner of Agriculture, while immediate supervision of disbursements was intrusted to resident county commissioners. Professor Waldron, on behalf of the experiment station, was instructed to remain in the field, visit every new locality of outbreak, and furnish all advice and assistance possible in the premises, remaining in personal control of the means of suppression at Orr and Inkster, which localities would serve for experimental purposes and as illustrations of restrictive measures for the benefit of other communities. At present areas of limited infection exist in Grand Forks, Walsh, Nelson, Towner, and Ramsey counties, the region of chief infection being along the Park River branch of the Great Northern Railroad for a distance of nearly 40 miles between Larimore and Park River, and it is here the only real damage has been wrought and the chief cause of apprehension lies. It is now confidently believed that with the vigorous measures adopted serious damage during the present season is not to be anticipated. The danger lies in apathy on the part of the public, which may result in the survival of a sufficient number of the mature insects to

lay the eggs of broods from which serious damage to next year's crops may follow, and it is with a view to prevent this contingency that the present information is placed at the disposal of the public. The measures for prevention are briefly, but fully, explained in the present bulletin, the material for which has been chiefly prepared by Prof. Waldron, perfectly familiar with the premises from actual personal experience. The measures recommended are simple, easily followed, and so cheap and effective that no excuse can be found for a failure to heed the warning and follow the suggestions offered. Further than this, it should be borne in mind that plowing, the chief dependence for prevention of the locust plague, has other advantages in the way of soil improvement and suppression of weeds which must fully compensate for any outlay required.

THE ROCKY MOUNTAIN LOCUST

(By C. B. Waldron.)

The habits of the locust are well known, and measures for their complete destruction are so cheap and simple that they can be carried out by simply varying the agricultural methods now practiced and not adding materially to their expense. No attempt will be made in this bulletin to give more of the habits and natural history of the locust than is absolutely required in dealing with the problem of extermination.

The eggs in the region named were doubtless laid during the latter part of August by locusts coming over from Manitoba and perhaps from Minnesota. Flights of the insects that were passing towards the regions now infested were observed on the 20th of August. The eggs were laid in stubble fields, as would have been supposed from our former knowledge of the habits of the locust and as subsequent investigation proved. If the presence of the locusts last season had been properly reported measures would have been adopted that, with no financial outlay, would have absolutely prevented the reappearance of the pest.

It has been found by repeated trials, particularly in Minnesota, that if the eggs of the locust are covered with 4 or 5 inches of moist earth, or 6 inches of dry earth, the hatching will either be prevented or the young will die before being able to reach the surface. It follows, then, that we may completely destroy the egg by plowing the fields in which they are laid, either in autumn or before the middle of June, at which time the hatching begins in this latitude. As the eggs are never laid in thick sod nor in loosely plowed earth it will be seen that plowing need not extend to any land except the stubble fields. If all the stubble land is put to wheat in the regular manner, the plowing to be done either in fall or spring, no word of complaint will come because of grasshoppers. If summer fallowing is adopted the plowing should be done in May or early June, and the land may be plowed again in the fall if considered necessary. This method of fallowing, if followed from the start, has the added advantage of destroying such weed pests as the Pepper Grass, "French Weed," etc.

Even if the plowing is not finished before hatching begins, it should be kept up until the stubble fields are all turned over. The period of hatching begins about June 1, or later if the land is lower, and continues about six weeks.

When the young grasshoppers are first hatched they are covered with a little sac, and by it enabled to push up through 2 or 3 inches of earth. If the grasshoppers are covered with earth after the sac disappears, from 1 to 2 inches is sufficient to kill them. One reason for continuing the plowing, then, is to bury and kill what insects may already be hatched. Even the grasshoppers that are not plowed under will be very apt to starve before escaping from the plowed land. As a rule it will be found well to plow a strip 5 or 10 rods wide right around the stubble field to retain

the grasshoppers inside, and then the rest of the field may be plowed in the usual manner. The insects will be driven toward the center of each land as the plowing proceeds. and the last furrows will be found to cover up great numbers, especially if plowed late in the evening or as soon as it becomes daylight in the morning.

If thought best, the plowing may not be finished at once, but a strip left in the middle of each land on which the grasshoppers may be caught, or the strip may be covered with dry straw and the insects destroyed by burning. Plowing the stubble field is an important step in fighting the locust in case much grass is found growing in the stubble. If the stubble is left standing the grasshoppers will be slow to leave their hatching ground if the food is abundant, and thus for several weeks the insects will be passing from the stubble to the wheat fields. The task of catching them is much shorter after the fields are plowed. In catching the locust several means have been employed at various times and places, but we will now describe only one, that being the one that from its cheapness, ease of obtaining and operating, and general efficency, seems to be best.

The apparatus referred to is the tar pan or hopper-dozer. The pan should be made of rather heavy sheet iron or ordinary galvanized iron. The length should be about 16 feet, width of bottom from 2½ to 3 feet, and the back about 2 feet high. The back may be made higher by a strip of gunny-cloth or a board, if experience shows the necessity. Along the front edge of the pan is placed a board from 1 to 2 inches thick and 4 inches wide. This is beveled on the lower front corner, so that the pan may pass easily over obstructions, and the iron that constitutes the bottom of the pan is brought around the front edge of this strip and nailed on top. The pan is further strengthened by a strip of timber along the back. The ends are of 1¼ inch plank, each bearing a clevis at the front for drawing the pan. The pan is drawn by two horses, one hitched in front of each end, on a rope about 10 feet long. Fastened to these ropes by a strong cord is a 16 foot pole so arranged as to drag about a foot in front of the pan so as to scare up the grasshoppers.

The pan is heavily smeared with coal tar, thus catching and holding all insects that jump in. It is a good plan to add a small amount of kerosene to the coal tar, so that the locusts may die almost as soon as entering the pan. Ordinary observation will enable a person to see when the insects should be scraped out and a fresh supply of tar added. The most effective time of day for using the dozer is toward evening when the insects are feeding. A pan working in this manner will catch several bushels a day in regions that are badly infested.

SIR: I have just returned from my canvass of the grasshopper region and find the situation to be as follows:

In general there appears to have been more or less egg laying over the whole region outlined in my former report to you. From Orr north to Park River this condition was modified largely by the presence of what I took to be a dipterous parasite, though I saw nothing but the larval form of this parasite and can not tell positively what it is. The larva was about one-fourth of an inch long and turned from white to a light brown on emerging from its host. In certain localities fully three-fourths of the *Caloptenus spretus* and *C. atlanis* were destroyed by the timely ravages of this parasite, but the *C. bivittatus* seemed to escape its attacks. In the vicinity of Larimore the parasite appeared but little. The region in which the greatest number of eggs is deposited is the southern part of Towner County in the vicinity of Cando. The *C. spretus* was abundant here and stayed till very late with no trace of parasites. The same condition exists all over Benson and Ramsey counties though in these last-named regions the grasshoppers themselves were far less numerous. The gospel of plowing has been so thoroughly preached that little danger may be expected except in what

may be called the outskirts of the grasshopper region, *i. e.* the western part of Walsh County, the southern part of Cavalier, and the northern half of Ramsey County. In these places many of the farms have been deserted and the chance for extermination thereby lessened.

Very truly yours,

C. B. WALDRON.

MIGRATORY LOCUSTS IN MINNESOTA IN 1891.*

(By Otto Lugger.)

The year 1891 has been remarkable, as far as insects are concerned, for a multitude of very noxious insects. Species, in former years rather uncommon, have appeared in vast numbers, causing more or less alarm on that account. A number of reasons may be given for such a state of affairs; but the present bulletin is not the proper place to discuss them. The chief causes may, however, be stated to be exceptionally mild winters and uniformly favorable growing seasons.

Among the numerous injurious insects of 1891 none are more dangerous than the various species of locusts or grasshoppers. Besides the native species, which in seasons favorable to locusts are always more or less injurious, we have to deal at present with three kinds of migratory locusts, *i. e.:* Rocky Mountain Locust (*Melanoplus spretus*, Thos.), Lesser Migratory Locust (*Melanoplus atlanis*, Riley), Pellucid Locust (*Camnula pellucida*, Scudd.).

In the report of the Entomologist to the Board of Regents, published in the Biennial Report for 1890, page 17, the following statement was made:

"But the danger of fresh invasion remains, and it is in the line of wise legislation to take time by the forelock, and provide the necessary means for suppressing another outbreak. The Rocky Mountain Locusts are becoming very numerous in their native breeding places, and have already produced some swarms extending beyond their usual haunts. In fact a large swarm of locusts passed on August 14, 1890, over Crookston, flying in a southeasterly direction. It is true the few mutilated specimens received by the Entomologist indicated three native species, but this material was insufficient to furnish proof that the 'Hateful Grasshopper' was not a member of this swarm. Through the kindness of the St. Paul, Minneapolis and Manitoba Railroad, the Entomologist was enabled to inquire into this matter, and found that this swarm had continued its flight from Crookston over Fosston, and had landed near to and in the upper Rice Lake, in the White Earth Indian Reservation, where the great majority of the insects composing this swarm perished. Some eggs were deposited near Crookston, and especial attention should be paid to the locusts resulting from them; but it could not be learned that others had been laid elsewhere. It will be very wise to recollect that the number of locusts in their home have reached the danger mark, and may, if favored by a suitable season, become not simply a menace but a reality."

After the publication of that report more material was received, which proved beyond doubt that the swarm entering the Red River Valley was composed mainly of migratory species. But even without such additional proofs it was quite certain that we had to deal with migratory species, as all our native ones, not being able to make extended flights, could not form such large swarms. Notwithstanding the evidence and warning of danger, no preventive measures were adopted and the intruders were allowed to settle in the invaded region.

Early in June a number of newspapers published complaints that locusts were doing considerable damage in some fields, but mainly near Pelican Rapids, Otter Tail County. A visit to that region indicated that a small swarm of locusts had deposited their eggs in that locality, but that timely work would suffice to kill all the

*Reprinted from Bulletin No. 17, Minnesota Agricultural Experiment Station.

young insects, as they were small at that time. The species found at Pelican Rapids was the Lesser Migratory Locust, reënforced by very numerous specimens of the two-striped species. No real Rocky Mountain Locust could be found. Later reports of damages caused by locusts in various parts of the Red River Valley reached his excellency Governor W. R. Merriam, who requested me to proceed at once to the infested region, and to do all that could be done at the time to prevent another outbreak of a locust plague. The Governor also instructed the county commissioners in the infested region to do all that could be done to stamp out the locusts in their respective counties.

When I reached the Red River Valley it was almost too late in the season to perform real effective work, as the great majority of these injurious insects had already acquired wings. Near Crookston, Polk County, the chairman of the county commissioners, Mr. Kirsch, had already commenced operations, and had done some very good work, both by plowing infested fields and by poisoning the grain growing upon adjoining ones. In fact, in several cases he had killed the insects to such an extent that but very few escaped. If his example had been followed everywhere the majority of the dangerous kinds of locusts would have been killed; but owing to a belief that the species found in such numbers was only a harmless one, few farmers adopted his methods, while many others even ridiculed the idea of having any migratory insects in the county at all. It is rather peculiar what strange freaks memory will play in some cases. Among others some farmers who had passed through former grasshopper troubles claimed that the Rocky Mountain Locusts were insects fully 2, 3, or even 4 inches in length, and that moreover were provided with six wings.

As soon as possible a large number of hopper-dozers were constructed and were distributed by County Commissioner Kirsch to all farmers who wished to use them. Both hopper-dozers and kerosene oil were furnished free by the county, and many farmers set to work to kill as many of the intruders as possible. The insects, being already winged and very active, could no longer be caught during the day; but towards evening, when they crawl to the highest points of the plant to escape the chilling effect of the moist soil, the machines proved of great value and immense numbers of locusts were killed. Various modifications of the hopper-dozers were used to suit the varying conditions of the fields and of the crops. Other intelligent farmers and merchants living in the counties of Marshall, and Kittson obtained models of these machines and commenced in earnest to destroy their enemy.

A close inspection of the invaded region showed that the sandy ridge running north and south through the counties of Polk, Marshall, and Kittson was more or less infested in spots. Without any exception locusts were found only in fields that had been plowed in July and August, 1890, or before the invading insects had deposited their eggs. In no case were locusts found in the native prairie nor in any soil that had been plowed late in fall or early in spring. These observations coincide exactly with those made a few years ago in Otter Tail County and indicate very plainly how to prevent locusts from causing injury in 1892. This inspection also showed that we have to deal not alone with one kind of migratory locusts, but with two other species equally injurious. Near Crookston the Lesser Migratory species is the most common one, but farther north the Rocky Mountain Locust becomes more numerous, and in the extreme north of Kittson County the Pellucid Locust is very abundant. The two former species prefer the dry and more sandy soil, the latter the richer and moist land.

The third species, the Pellucid Locust, now injurious in the Red River Valley, is quite different from any of the above three species. Many other locusts occur in large numbers in the infested region and are frequently mistaken for the migratory species. A close inspection of the illustrations below will show that they are quite different, and need not, with a little attention, be mistaken for any of the migratory species.

The common native Two-striped Locust is very numerous throughut the infested region, doing considerable damage.

Remedies.—Besides the usual methods of killing locusts, some of which are very valuable if carried out at the proper time, there is but one other excellent remedy left to prevent further injury: plowing the ground after eggs have been laid. This remedy has been applied two years ago on a large scale in Otter Tail County and has proved a complete success. As the conditions in the newly infested regions are similar, there is no doubt that similar results will be obtained if the same remedy is carried out thoroughly. All the locusts now infesting the invaded counties came from fields that were not plowed. In places where the whole of the cultivated soil was plowed, no locusts could be found. Of course at the time of writing this bulletin the state of affairs is different, as the insects have scattered over a much larger area. But if every farmer will plow all his stubble land either this fall, after the eggs have been laid, or in early spring, no fears of losses by locusts need be entertained. But to make the reader understand the case more clearly, it is necessary to describe in detail how the eggs are laid and what effect plowing will have. I quote from Bulletin 8, published by the Station during July, 1889.

To repeat again: "If we desire to get rid of the migratory species of locusts now infesting several counties of the State, it is absolutely necessary to plow every inch of the cultivated ground throughout the invaded region. Of course prairies are excepted, the soil in them being filled with a dense mass of roots, thus being unsuitable for the purpose of egg-laying. Simply cultivating in spring, as advised by some, is perfectly useless and proved a total failure where tried. Summer fallow invites the locusts to deposit their eggs in soil thus prepared, and all land thus treated must be plowed again, either later in autumn or early in spring."

Natural remedies.—There are at this time many natural agencies in our favor and working for us, and no doubt immense numbers of locusts will be killed by them. Nearly if not quite all the parasites known to infest locusts are found in large numbers throughout the invaded region. In some places the Red Mite was found in immense numbers infesting not alone the bulky Two-striped Locust, but also those migratory species which love drier soil. In some fields in which the locusts had hatched nearly every individual had from five to twenty of these mites fastened to its under wings and the locusts were doomed. Evidently they knew this as well, as they did not move about in such a lively manner, but seemed out of sorts. But these were exceptional cases, as all the adjoining fields of wheat were overrun with healthy specimens—too healthy to suit the farmer. The explanation lies in the fact that the healthy locusts had escaped all danger from the Red Mites by migrating to the land of plenty, the wheat fields. Numerous other parasites occurred almost everywhere, but chief among them was one of the "old-fashioned" Potato Beetles, or Blister Beetles. This insect (*Epicauta pennsylvanica*) was so numerous as to seriously injure the potato crop. And yet, though very injurious to potatoes, this beetle ought to be protected for once, as in its earlier stage it feeds exclusively upon the eggs of the locust. Many predaceous insects are also in full operation to reduce to some slight extent the numbers of the intruders. It was a cruel yet withal a pleasant sight to see the large numbers of Ground-beetles (*Calosoma calidum*) giving battle to the locusts. Even large specimens were attacked, and notwithstanding a most desperate struggle the locust was soon consumed. Another beetle (*Pasimachus* sp.), much more shy in all its actions, being a nocturnal insect, was found in large numbers engaged in devouring the enemy. Even spiders assist in this good work, and a number of the common Wolf Spiders (*Phydippus tripunctatus*) were seen to attack and kill locusts.

Report to his Excellency Governor W. R. Merriam in regard to the Migratory Locusts infesting portions of Minnesota.

On August 14, 1890, a large swarm of locusts or grasshoppers entered the State of Minnesota. They were observed in a number of places, but chiefly at Crookston, Hallock, and other points in the Red River Valley. This swarm came from the northwest and flew in a southeasterly direction. Through the kindness of the Great Northern Railroad I was enabled last summer to make close inquiry in the regions where this swarm had been observed, and I could follow one that had passed Crookston in an easterly direction to Fosston into the White Earth Indian Reservation, where immense numbers of the locusts composing it had perished in the upper Rice Lake. Close inspection also revealed the fact that eggs had been deposited in some places. At the time in which the above investigation was made it was impossible to obtain many specimens of the insects composing this swarm, but the mutilated material obtained indicated, besides the common native species, at least two species of locusts not usually found with us, one of which was the Lesser Migratory Locust (*Melanoplus atlanis* Riley) and the second a locust evidently belonging to a different genus, but not identified at the time.

As our native locusts do not form swarms like the one invading Minnesota on August 14, 1890, it was quite certain that we had to deal with species more formidable and dangerous, and I deemed it my duty to call attention to this invasion, stating that it was in the line of wise legislation to take time by the forelock and provide the necessary means for suppressing another outbreak. This was done in the last Biennial Report of the Agricultural Experiment Station, page 17. For some reason, however, no action was taken.

When a swarm of locusts passes a region the females, heavy with maturing eggs, are very apt to lag behind and drop to the ground whenever the soil is of such a character as to invite them to deposit their eggs. Suitable for such a purpose is all soil that is well drained and which contains very few roots of plants.

Early in June of the present year a number of letters were received from different parts of the State about exceptionally large numbers of locusts. This was to be expected, even without the addition of the migratory species, as the last few seasons had been greatly in favor of all kinds of locusts and other insects that thrive best in dry and hot summers following a mild winter. The first alarm, in the form of articles in some of our daily papers, came from Pelican Rapids, in Otter Tail County. My investigation of this case showed that a small area near that place had been infested, but chiefly by various native species and the Lesser Migratory Locust. Paying proper attention to this local trouble removed cause for alarm.

The attention of your Excellency was next drawn to the more alarming reports coming from the Red River Valley, and you ordered me to proceed at once to the infested region, and for the last forty days I have been engaged in traveling through the different counties invaded and in instructing farmers in the proper means to combat their enemy.

In Minnesota five counties are infested with migratory species of locusts. Three distinct species, besides the native, are now causing well-founded alarm. The Lesser Migratory Locust (*Melanoplus atlanis*, Riley) is the most abundant species. The true Rocky Mountain Locust (*Melanoplus spretus*, Thomas) is also very common, and the Pellucid Locust (*Camnula pellucida*, Scudd.) occurs also in alarming numbers in the more northern part of the invaded region. The Two-striped Locust (*Melanoplus bivittatus*, Scudd.), though a native species, is exceedingly numerous in many places and causes considerable damage.

The Lesser Migratory Locust occurs in very large numbers in parts of the counties of Polk, Marshall, Kittson, Ottertail, and Hubbard, and extends eastward as far as the cities of Duluth and Tower, St. Louis County, and is doubtless found in more isolated swarms in the whole northern part of the State. The Pellucid Locust

occurs only in the lower or moister parts of Kittson County, and is also found in considerable numbers at Pembina, N. Dak.

We have to deal in this instance with three of the worst species of locusts found in the United States. The region invaded is quite well defined, and the insects occur thus far only in certain spots, but of course this state of affairs will be somewhat changed during the month of August. The central parts of Polk, Marshall, and Kittson Counties from south to north are more or less affected; or, in other words, the sandy ridge running from south to north in above counties is invaded by the Lesser and by the Rocky Mountain Locust. Evidently this sandy ridge attracted the females to deposit their eggs, or the eggs laid elsewhere in the black and more moist soil did not hatch. The former theory is very likely the true one, as the instincts of the female prompt her to deposit her eggs wherever there is good drainage, an important factor to the well-being of the eggs of those insects. But not the whole of this more or less sandy region is thus infested, as the locusts occur only in well-defined small areas. A close inspection of several hundreds of fields revealed the undisputable fact that all eggs laid by the invading swarm were laid in stubble fields and in summer fallow. In no case were the locusts found in the prairie or in fields not surrounded by or adjacent to stubble fields. All the dangerous locusts hatched there and thence invaded the neighboring fields of grain. In a large number of cases the young locusts marched in regular order to the fields of barley, wheat, and oats, and swept away every trace of vegetation for several rods, in some cases many acres. As they grew older they scattered around more, and the exceedingly rank growth of the grain shows at the present time but slight damage. In badly infested fields, however, nearly all the foliage has been eaten, and the heads alone remain. Even these are now devoured in many instances, but only in the more sandy regions. There is still considerable danger to the crops in some parts of the infested regions. As the foliage of the various kinds of grain becomes older and riper it becomes also unfit for food, and the locusts will be forced to attack the growing part of the plants, the heads. In some fields this is already the case, and the locusts eat out the growing kernel, or even bite off the whole ear.

Both the Lesser Migratory and the Rocky Mountain Locust infest mainly the more sandy and drier region of the invaded county. The Pellucid Locust seems to prefer entirely different localities, and is at the present time only found in the lower and moister regions, chiefly in the northern part of Kittson County, and in the corresponding parts of North Dakota. There it is quite injurious, and may prove even a greater enemy than either of the other migratory species.

All these locusts, although very numerous in some regions, are as yet not numerous enough to cause very serious loss to the general crop. Many farmers will lose a large part of their crops; some few may lose even everything.

All these species of locusts, being fresh arrivals from the Northwest, are in a remarkably healthy condition, and consequently much more dangerous than if they had been here some time longer. The two species, loving dry and warm soil, show this to a remarkable degree. If stubble fields in which the eggs were laid are investigated at this time it will be found that fully one-half of the locusts are infested with their deadly enemy, the Red Mite, and this in most instances to such a degree that they will be disabled and unable to deposit eggs for another generation. But if we investigate the adjoining fields, with their promising crops of grain, we soon discover a very different state of affairs. Here almost every locust is free from parasites and enjoying life in grasshopper fashion to the fullest extent, and the intruders will be able to deposit immense numbers of eggs. Evidently the locusts infested with parasites take a gloomy view of life, and have lost their usual energy to such an extent as not even to migrate to the adjoining land of plenty. The common Two-striped Locust of the Red River Valley, although quite an injurious insect if numerous, is now badly infested with numerous kinds of parasites and is consequently to be considered as a friend, since the parasites infesting it will next spring take pos-

session of the invading species. All the important species of parasites occur in fairly large numbers throughout the infested region. One species, the common Black Blister-beetle, is at this time so numerous as to seriously damage the potato crop; it is even much more numerous and injurious than the Colorado Potato-beetle.

Considering the locust invasion in all its bearings, the true state of affairs may be summed up in a few sentences. There are not enough locusts to seriously injure the crop of 1891, though some farmers will lose considerable. Many parasites are at hand to assist us in 1892. The great bulk of the invading species are still remarkably healthy, and will lay enough eggs to produce immense swarms in 1892 if not prevented by artificial or natural means. They are still local, and can be exterminated by energetic and prompt means.

Your Excellency, knowing the great danger of another locust trouble, perhaps similar to that experienced from 1872 to 1876, has taken the only possible way to prevent it by instructing the county commissioners of the infested regions to take the proper steps for fighting these insects. Some of the commissioners thus called upon have responded cheerfully and have acted at once, but others do not seem to consider the locusts as dangerous enough to cause serious losses. Such a view is very short-sighted. Even if these injurious insects do not seriously endanger the crop of 1891, they will assuredly do so in 1892 if not stamped out in time. "An ounce of prevention is worth a pound of cure" is an old saying, but a very true one, and ought to be made the leading impulse in our work against these intruders. In Polk County a large number of hopper-dozers have been in operation under the intelligent and energetic leadership of the chairman of the county commissioners, and have done good execution. As all the locusts, or nearly all, were already winged when the machines were put in operation, very little could be done with them during the warmer parts of the day, but late in the evening, during the night, and early in the morning, when the insects are sluggish and crawl up to the highest parts of the plants, immense numbers were killed, and many fields could thus be saved. At the present time the grain is too far advanced to use such machines, except in extreme cases. The only remedy, and the only one that will effectually do the work, is plowing all the fields known to contain the eggs of locusts. If a good crop is secured next month a large portion of the cultivated land will be plowed, thus killing off immense numbers of locusts in 1892. But all the other cultivated land should also be plowed after the eggs have been laid. The locusts have commenced to mate and will soon deposit their eggs, and continue this work until sometime in September. This time of egg-laying depends, of course, upon climatic conditions, and may be greatly shortened or lengthened. At all events, however, no land should be plowed before all the eggs have been deposited. If already plowed, or plowed before the eggs have been laid, a second plowing later in autumn or as early as possible in spring will be absolutely necessary. The locusts prefer ground free from roots and well drained. Such ground we furnish them now by summer fallow and later by early plowing. All fields treated in this manner are very suspicious and ought to be plowed again.

I have recommended that instead of summer fallowing, to plow now only to a depth of 2 inches and later to the usual depth. Concerted action is absolutely necessary, and the ignorant or slovenly farmer should not be permitted to endanger the future crops of his neighbors and perhaps that of a large part of the State. The county commissioners can help greatly in this good work, and should, if necessary, force all farmers to do their duty to themselves and to their fellow-farmers. In this connection permit me again to call your attention to the fact that the State of Minnesota needs some laws to protect the good farmers against injurious insects raised by the poor ones. Locusts ought to be classified with certain contagious diseases, like the smallpox, for instance, and similar laws ought to be framed to suppress these insects as such diseases.

Generally speaking, the climatic conditions prevailing this summer have been

greatly in favor of the farmer and have been and are against such of the migratory species of locusts as love and thrive best in a hot and dry season. This will account for the fact that but few locusts have been seen flying long distances. The great abundance of moisture has made them sluggish and prevented their flight. Long continued moisture is very injurious to insects of that order, and may greatly assist us by diminishing their number, by enfeebling many, and by preventing the depositing of eggs, except in certain regions well drained. But it would be very unwise to trust entirely to such favorable climatic conditions or to any other natural means to help us. We must help ourselves, and only conscientious work will attain that end. If favorable climatic conditions should assist us it will still be necessary to inspect carefully all infested or even all suspected fields, and have them plowed regardless of cost.

As usual in such cases, the railroads in the infested regions have shown their interest in the war against the locusts, and thanks are due to both the Great Northern and Northern Pacific railroads for furnishing free transportation over their lines.

Very respectfully, yours,

OTTO LUGGER.

ST. ANTHONY PARK, MINN., *August 1, 1891.*

THE LOCUST PEST IN IDAHO—SUMMER OF 1891.

Soon after returning to Lincoln, Nebr., from the Washington meeting of the official entomologists of the country, I started for the West to investigate the actual condition of the locust plague in central Idaho. Although the season had advanced beyond the time for the best results to be obtained from such an examination, it was still thought advisable to visit the region known to have been overrun last year. Especially was this thought the proper thing to be done since a number of appeals for aid had been received by the Department from citizens of the infested region. Leaving Lincoln on the morning of the 27th of August, Soda Springs, in the southeastern part of Idaho, was reached early on the morning of the 27th. At this point the first stop was made for the purpose of ascertaining whether or not the locust plague had reached this portion of the State. Two days were spent here, during which time much of the surrounding country was visited. While no locust pest occurred here it was plainly noticeable that *Camnula pellucida* was greatly on the increase since last year's visit. This locust was quite abundant upon the hay fields and along all irrigating ditches. Inquiries among the various ranches from some of the surrounding valleys indicated about the same condition of affairs at all points. On the 29th I went on as far as McCammon, on the Port Neuff River. Here *pellucida* was also rather commoner than usual, while *Melanoplus atlanis* and *M. femur-rubrum* were too plentiful to inspire one with thoughts of peace from the standpoint of locust ravages in the near future. Next day a stop was made at Pocatello and another at Shoshone. At this latter place it was learned that the locusts had been exceedingly numerous about four to six weeks previously, having come down Wood River from Camas Prairie, doing much damage as they went. A few eggs were also reported to have been deposited in several localities below

Shoshone; but how extensive these egg deposits were could not be definitely ascertained at the time. If the main body of the locusts had moved on down the river as reported there were still plenty of them left behind to mark the line of march, although this could easily have been detected without the presence of these stragglers. The bared fields and cropped grasses on the range alone were sufficient to mark the line of march of the ravaging army.

At first the locusts that were seen from the train at stations along the line of the railroad were mostly *pellucida;* but, as the mountains were approached, several species of *Melanoplus* were also noticed in considerable numbers. In the vicinity of Hailey the pest was quite apparent in the damaged condition of the grasses on the range, as well as in the appearance of the vegetation upon cultivated grounds. The scourge had passed through here before going down the river towards Shoshone; and, as appearances would indicate, this swarm divided at Spring Creek, a part of it going to the eastward towards the Lost Rivers and Birch Creek, all three of which streams with their valleys were reached by the moving hordes of hungry insects, the other portion, as already indicated, going down Wood River past Shoshone.

A stage ride of 31 miles across the mountain and valley brings one to the town of Soldier in the center of the rich Camas Prairie country—a valley of considerable extent and wonderful fertility. This valley has been the cradle for the present locust plague which is now spreading over the surrounding portions of the State. Five years have elapsed since the insect was first observed on the prairie in destructive numbers, but with each successive year the plague has greatly increased and spread over more territory. At first the pest covered but a few square miles of country and did but little damage; the next year it became noticeably more numerous and began moving outwards in various directions from the center of its hatching place, and much more damage was done both to grasses and to grain and other cultivated crops then growing upon the fields of the few settlers who had located and started homes for themselves in the valley. Even at this time it would have been possible to have exterminated the pest in the valley had only a few determined persons attempted to do so. By the time the third summer had come and gone, along with its increase in the numbers of locusts present and the amount of damage wrought, the settlers began to become discouraged. Still no efforts whatever were made towards mitigating the evil. This third year of the pest was a notable one, since just before egg-laying time arrived every single hopper was reported to have left the low lands in the valley for the foothills adjoining, where they laid their eggs. As most of the insects moved in a northeasterly direction when leaving the valley, this movement gave some new hopes to the, by this time, nearly discouraged settlers, for it was hoped that instead of reëntering the valley the young, upon hatching the following spring, would pass on to the northeastward. The ensuing

winter was one of uncommon severity even for this region, with very deep snow, which, upon melting the following spring, flooded the low lands for a long time. The great amount of water throughout the region caused rank growths of vegetation everywhere. Soon after the hillsides began to be denuded of their mantles of snow and vegetation started, the young locusts began hatching and feeding. Contrary to the expectations of many of the inhabitants of the prairie, the feeding and growing hoppers showed little disposition to move away from the locality. Once, it is stated by several persons who had taken the trouble to watch their movements, these little locusts did start off towards the summits of the mountain chain lying to the north. This was just before they developed their wings and while in the pupal stage. But just as soon as they had wings, and these latter had become sufficiently hardened for use, the entire swarm turned about and dropped upon the valley, massing upon the fields of grain and gardens, which they stripped in a remarkably short time. When all cultivated vegetation had disappeared the native grasses were attacked and devoured. So numerous and voracious were the locusts that, notwithstanding the rank growths caused by the abundance of water during most of the spring and summer, when I visited the region in August the country was pretty well divested of its covering of vegetation. Instead of leaving the valley for the hills as their immediate ancestors of the previous year had done, these locusts of 1890 remained and laid their eggs in the valley, choosing gravelly or somewhat sandy places for the purpose. At the time of my visit most of the eggs had already been laid, and hence it was rather a difficult problem to ascertain the exact extent of these depositions, since but few people in the region had paid the slightest attention to the matter, even after a fourth year of suffering had been passed through. It appears, however, from the number of young locusts that were hatched the past spring that a great portion of the valley was thus occupied.

My examinations of the locusts that remained in the valley at the time of my first visit led me to believe that the plague was about at its height, and I so reported at the time. Whether to have done so was the wisest plan or not I can not say, for on the strength of that report most of the inhabitants of the valley decided that there was no further necessity for fighting the plague—a thing that they had not done in the past nor probably had any idea of trying in the future. There certainly were a number of diseased and parasitized hoppers in the country, besides the entire region was overrun by young toads that promised to be of value the following spring in devouring the young locusts when they hatched. It will be seen by the following account of the locusts in that region during the past spring and summer that my conjectures were probably correct. Although apparently on the decline in Idaho, this particular species of locust covers a much more extended area of country than it has for a number of years.

The winter of 1890–'91 was milder than that of a year before, and less snow fell in the valleys and on the prairie, while just as much or probably more fell in the mountains. Spring was slow in coming, and when it came heavy rains set in with the result of flooding much of the prairie. These rains continued through May, June, and pretty well into July. The eggs left by the locusts the previous year began hatching in due time, and of course the little hoppers to feed. Simultaneously with their hatching and eating they began moving slowly toward the lower end of the valley. Whether all of these were inspired alike with the desire to forsake the region of their début into the world I do not know, but, judging from what little information on this point that I was able to obtain, this desire seemed to be almost unanimous. Be this as it may, perhaps a description of the general lay of the country will better explain what followed later in the season.

Camas Prairie is composed of the valleys of the Malade River and its tributaries, which form a basin-like region lying back of the great Snake River Plain and separated from it by a low range of volcanic mountains. This basin averages about 10 to 12 miles in width and is perhaps between 50 and 60 miles in length. The trend of the valley is from west to east, and its lower end is about 1,200 feet lower than the head. At Soldier, which is near the middle, the elevation above sea level is about 5,300 feet. The Malade River, which is the main stream of the prairie, runs along quite near its southern border, and most of its tributaries enter from the north, where they have their sources among the high mountains. Most of these streams flow in a southeasterly direction across the prairie after leaving the mountains and before entering the Malade.

As before stated, the young locusts, just as soon as they hatched, began moving down the valley. Coming to these different side streams they were unable to cross and hence were obliged to stop. Soon their increasing numbers from daily reënforcements devoured what vegetation there was at hand and they perished from starvation. So say some of those with whom I talked about this feature of the subject under treatment. Others claimed that the little 'hoppers were smitten by disease and perished by the millions from that cause; but, whether from starvation or on account of disease, myriads of them died and were washed away by the waters of the swollen streams and piled upon the banks in great heaps from which, as the heat of summer increased, a stench arose that was very disagreeable to say the least, if not actually dangerous to the health of the inhabitants. Even as late as the 10th of September remnants of these heaps of dead locusts were visible along the banks of Soldier Creek and the Malade River. Notwithstanding the great numbers of these insects that perished during the early part of the season when the country was flooded with water, there were still enough of them left to do more injury to the grain and grasses than was done in the valley the year before. Some

of the ranchers lost all of their grain, while others threshed barely as many bushels as they planted, and none harvested a full crop.

Just as soon as those insects which succeeded in pulling through the wet spring obtained their wings they left for the hills—and there was a host of them that did pull through—most of these passed off to the eastward; but others crossed the low range to the southward and southwest, while a few lingered in the hills and mountains to the north of the prairie. It was lucky, too, for many of the settlers, for the grasses were thus allowed to grow somewhat afterwards for hay. Otherwise it would have been impossible to obtain feed for their stock during the coming winter.

It is hoped by the settlers of Camas Prairie that the greatest danger from this pest has passed, and if the reports in reference to egg-laying for the past summer can be depended upon, I am of the same opinion. It is claimed that but few eggs were laid on the prairie proper, and not many more amongst the surrounding hills and mountains. I must confess that my search for the eggs of this insect while in the region was not very successful; still, there might have been quantities of them in districts not visited or examined. No one can more earnestly desire to see this region free from the pest than I do, for my two visits to the region have brought about a liking for the country, and I have also made many friends among the inhabitants whom I wish to see prosper. Aside from these personal feelings a desire for general welfare prompts me to hope for a speedy relief from the plague. Eggs are known to have been laid at three or four places upon the lower mountains to the north of the prairie, and others in the hills south of the Malade. None of these egg areas, so it is claimed, comprise more than a few acres each.

As would naturally be supposed, the presence of the pest in the same region for a succession of four or five years has resulted in the production of several of its natural enemies in rather abnormal numbers. These, of course, are doing much towards mitigating the evil, but as yet they do not appear to have made much of an impression upon the vast throng comprising this plague. Several natural enemies of this locust were observed, such as the Locust Egg-mite (supposed to be the same species that worked on the eggs of the Rocky Mountain Locust in Minnesota and other sections of the temporary region), several of the *Tachinidæ* or Flesh Flies, three or four kinds of Robber Flies (*Asilidæ*), some of the Ground-beetles (*Cicindelidæ* and *Carabidæ*), a couple of species of Blister-beetles (*Meloidæ*), and one or more of the Wasps (*Crabronidæ*). Besides these, during late summer and early fall, the streams of the region were full of one or more species of hair worms (*Gordius*), which most likely had been parasitic within the bodies of this and various other locusts. If everything would continue thus favorable for the increase of these natural enemies of the locust, they themselves would eventually control it; but as their existence is also to a great degree dependent upon certain climatic conditions, it is not a safe plan

to trust too implicitly in them. The settlers must themselves take a hand in the fight if they would be sure of victory. As shrewd as are most of the living things about us, man is shrewder still. Hence, if he undertakes in earnest the task of outwitting any of these lower forms of life, he is bound to succeed. True, there are often many difficulties, apparent or real, to be overcome, but a little judicious planning in the end brings success.

The habits, life-history, and haunts of the Pellucid-winged Locust differ materially from those of the Rocky Mountain or True Migratory one which has received so much of our attention during the past twenty years, and which has finally been obliged to yield the ground to us on account of the mode of warfare adopted. Still, the characteristics of *Camnula pellucida* are essentially similar, and slight modifications in the mode of warfare as used against the former insect will be successful with the latter. The use of the "kerosene pans" or hopper-dozers is quite practicable in most cases against the pest upon the valleys, while plowing for the destruction of the eggs before hatching can be resorted to in a number of instances, both upon rolling and level ground. All this requires work. So does the destruction and keeping down of noxious weeds.

While matters begin to look more hopeful with reference to the Pellucid Locust, upon Camas Prairie at least, I am sorry to be obliged to report that there seems to be a decided increase among several other species of these insects now in the region. Of these latter there are the Lesser Migratory Locust (*Melanoplus atlanis*), the Detestable Locust (*M. fœdus*), the Two-striped Locust (*M. bivittatus*), and *Pezotettix enigma*, for which there is no common name. All four of these locusts were quite plentiful at various points upon the prairie, and especially so in the vicinity of the foot-hills on the north side. In certain localities they were sufficiently numerous to materially injure the grasses and other natural vegetation, and at a few points even did noticeable injury to cultivated crops that had escaped the ravages of *Camnula pellucida* earlier in the season. Of course the undue multiplication of these various other locusts is caused by the same favoring conditions which allowed the *pellucida* to develop in such overwhelming numbers. Whether or not, since most of the swarm of that one has left the valley, these latter will be attacked by the great numbers of enemies which its presence permitted to develop and which it left behind, remains to be seen.

THE DESTRUCTIVE WESTERN CRICKETS.

While not exactly locusts, these large wingless insects which are usually known by the name of Western Crickets need mention in this connection. A number of years ago, during the days of geological survey expeditions, and when the first fieldwork of the United States Entomological Commission was being done, these insects were frequently seen in immense droves moving over the country like so many sheep.

During more recent years, however, they have been less numerous, and hence but little has been heard of them. The true home of one of these insects is the great plains of the Snake River, where sage brush reigns supreme as the vegetable product of the country. Beyond this limited region the insect is only occasionally met with in droves. Its distribution reaches over the Great Salt Lake Basin into northern Oregon, on the Spokane Plateau of eastern Washington, into a few of the valleys of western Montana, and at long intervals it is even met with in western Wyoming. In addition to this species, which has been called *Anabrus simplex*, there are quite a number of allied species, to be met with in the same region as well as elsewhere. The most of them are, however, denizens of the arid and semi-arid regions of the West and Southwest, where they either wander about singly or in pairs, feeding upon the scant vegetation. As a rule each species is confined to a rather limited area, and prefers some special plant as its leading diet. As with all other rules, there are exceptions to this one also. A few species of these crickets have a very wide distribution and enjoy a greatly varied diet. Some species are inhabitants of elevated mountain slopes and valleys, while others occur far out on the grassy plains of Nebraska and Kansas.

As a group this subfamily *Decticidinæ*, among the other Orthoptera, has been greatly neglected in our country. But few of the forms have thus far even been honored with a scientific name, to say nothing of their life-histories, habits, enemies, etc., which are still to be learned. Truly, they have thus far been a neglected lot!

The reason for my speaking of these crickets now is the reappearance of two species of them during the past season in great numbers over a considerable territory. Early in July it was known that a swarm of *Anabrus simplex* was forming somewhere in the region between Mountain Home and the Camas Prairie country, where they had hatched earlier in the season from eggs laid last fall. After forming, this main swarm of the insect started in a northeasterly direction, crossing the divide and entering the prairie nearly south of the town of Soldier. After entering the valley most of the insects kept right on their course which they had apparently chosen, but many of them left the main body and scattered over the whole region drained by the Malade. Judging from the information obtainable, this must have been a very large swarm indeed, for it was claimed that the insects covered a tract nearly or quite 3 miles wide by 9 miles long. I first met the insect in considerable numbers a couple of miles out from Hailey, and found them more or less plentiful at various points along the road for 20 miles. They were seen again a couple of days later in the foothills north and west of Soldier, where a few of them were still apparently depositing eggs. While engaged in this act the female becomes so intent upon her work that she can be approached and watched without being at all disturbed. The long strong ovipositor is gradually worked into the hard earth by a series of backward and

forward sliding thrusts, with an occasional side movement. In this manner the hole thus formed becomes a little elongate in form and somewhat larger at the lower end than above, making an enlarged cavity for the reception of the eggs, which are irregularly arranged. These eggs are somewhat curved, of dark brown color, of an average size for the insect which lays them, being nearly one-third of an inch in length and are somewhat flattened, but otherwise do not differ much in form from those of an ordinary grasshopper, or locust as they should be properly called. They are not all laid at one time, but, judging from dissections made of the female, 15 to 18 are laid in one cluster, other deposits following at intervals of several days during the fall. Last summer they began laying about the middle of July and continued during the first week in September. It was not definitely settled as to the arrangement and number of eggs laid in a single cavity, but the figures given above can be taken as approximately correct.

A second, but much smaller, species of these crickets also occurred in numbers near and among the foothills of the mountains adjoining the prairie. This latter species is evidently the one described by Prof. Cyrus Thomas as *Decticus trilineatus*, though from its great variability in coloration and markings it is quite difficult to decide this for a certainty without careful comparisons of a number of specimens with the description. Contrary to the clumsy movements of the large *Anabrus simplex*, this smaller cricket is one of the most active insects in the region, and to capture a specimen of it during the warmer part of the day requires considerable dexterity on the part of the would-be captor. Its egg-laying habits were not ascertained since it apparently had not yet begun operations in this direction.

Some apprehension is felt by many of the inhabitants that this latter insect will also become injurious, since it was noticed for the first time the present year in such numbers as to cause alarm. I do not think that such is liable to be the case, since it appears to be partial to damp places covered with rank vegetation rather than to the more dry open country. It occurred in the mountains at an altitude of 9,000 feet above sea level or near timber line, as well as down in the valley below the 5,000 feet point.

The migratory habit in *Anabrus simplex* and several others of these large, wingless, cricket-like insects is very marked at times; but much more so when they are present in large numbers. As with many other insects when they develop in excessive numbers, the desire to move in great crowds seems to take hold of these crickets. At such times they move towards central points and congregate into companies, after which they strike out in a body in some particular direction. When moving they are said to turn neither to the right nor to the left, but to keep on in a direct line, climbing over obstacles rather than going around, and even plunging into streams which happen to run across their course of travel. When these streams are encountered, if not too

large, they are soon filled to such an extent that the oncoming hordes soon are enabled to cross over on the bodies of the unfortunate leaders that reached the stream first. It has never been my fortune to see a swarm of these insects crossing anything larger than a small irrigating ditch, hence it is a difficult matter for me to accurately describe one of these crossings. They are also said to be capable of being driven "just like a drove of sheep" when they have stopped to feed; and at such times are often "herded" off gardens and fields of grain.

LOCUST INJURIES IN OTHER REGIONS DURING THE SUMMER OF 1891.

Before closing this report it might be well to refer to such other locust depredations occurring during the summer as have directly or indirectly come to my notice. Of course, these were most of them quite local and limited in their extent, and were occasioned by local non-migratory species. Taking them at random rather than in accordance with their magnitude or importance they can be briefly stated as follows:

A region of considerable extent in southwestern Kansas was overrun to some extent by the large yellow locust known as *Melanoplus differentialis* and several other species in fewer numbers. These mostly damaged the alfalfa and materially lessened the hay crop of that region. Professor Osborn, of the Iowa Agricultural College, who visited the region by your request, has already given a full account of this outbreak in a paper read before the meeting of official Economic Entomologists, held in Washington during the month of August. Hence, I will merely refer to it here.

Farther south and west, in New Mexico and Arizona, locusts were reported as being very numerous and moving eastward. It was claimed in the reports that the damage being done here was chiefly to the grasses on the range. Just what species of 'hoppers were engaged in these injuries, and how extensive they were, could not be learned at the time. Possibly it may have been the Long-winged Locust which also occurred in Colorado and did like injury there. At any rate the mention of their "moving in droves while yet unfledged" would be quite characteristic of the *Dissosteira longipennis*. Letters received from Professor Townsend, of the New Mexico Agricultural College, quite recently, throw a little light upon some of the locust injuries wrought in that particular region during the year. He states that the *Acridium shoshone* and a species of *Melanoplus* have been numerous during the past summer and were the cause of some slight injury to certain crops and wild plants. The *Acridium shoshone* worked on the Mesquite and other shurbs and trees, while the *Melanoplus*, which was probably the *differentialis*, attacked and slightly injured the vine.

Reports also reached us here in Nebraska that there were locust depredations being committed in portions of Texas. These reports were found in the columns of the daily newspapers. Just how extensive and at what particular point these injuries occurred in that State I

have been unable to determine. A Government agent was sent out to investigate this particular region, but, I believe, was unable to locate it. It is quite possible that it was some very local injury caused by the *Melanoplus robustus*, *Dendrotettix longipennis*, or *Schistocerca americana* that gave a foundation upon which to build these reports, which afterwards grew as they traveled. Or, it may be that this and other reports of the presence of grasshoppers in destructive numbers which agents afterwards failed to substantiate originated with newspaper correspondents who did not wish to be outdone by co-workers in other sections of the country who had reported bona fide swarms of these insects.

Here in Nebraska there has been more or less injury from *Melanoplus differentialis*, *M. bivittatus*, and *M. femur-rubrum* during the summer; but nothing serious has occurred, nor is there any indication of special injury for next year. This injury during the present year has been confined principally to cities and towns where poultry and wild birds do not have access to old weedy gardens and vacant lots where the 'hoppers are allowed to deposit their eggs and hatch from year to year. Hence the increase and subsequent injury.

While in attendance at the Washington meeting of the Association of Economic Entomologists last August considerable interest was manifested by those present in the locust question for the country at large during the present season. In the discussion that followed the presentation of several papers bearing upon the subject, different entomologists reported the presence of larger numbers of these insects than usual in Alabama, Mississippi, Michigan, New York, Ohio, Indiana, and Iowa. Of course different species of these insects were the guilty ones in different regions; but for the most part *differentialis*, *bivittatus*, and *femur-rubrum* were responsible for such injuries in these States, from which we have no special reports.

These reports of locust injury, coming as they do from almost every section of the country, tend to show that the insects of this group are greatly on the increase, and that unless checked by natural causes, or unless early efforts are made by the people interested to check them, much greater injury must be expected in the near future. True, this excessive increase in so many species and over so wide a scope of country is due to some special cause or combination of such causes, which may seldom or never occur again. Still there is no telling what the future may hold in store. So the wisest plan, by far, as already intimated, is to help ourselves wherever we can. In the present case in particular it should be our aim to do this, since it has been demonstrated time and again that these locusts can very readily be kept in check by ordinary means.

REPORT ON THE LOCUST INVASION OF CALIFORNIA IN 1891.

By D. W. Coquillett, *Special Agent.*

LETTER OF SUBMITTAL.

Los Angeles, Cal., *October 15, 1891.*

I submit herewith a report of my investigations of the locust invasions of California during the past season. These investigations were made principally during the month of August, and conducted in accordance with your instructions of July 27, 1891.

Respectfully yours,

D. W. Coquillett.

Prof. C. V. Riley,
U. S. Entomologist.

According to directions I proceeded, on July 30, to that portion of the State invaded by the locusts, or grasshoppers, stated in the telegram to extend from Merced on the south to Redding on the north. South of Merced County I did not learn that any great amount of damage had been done by the locusts the present season. In portions of Kern County I was informed that the locusts had attacked Apple and other kinds of deciduous fruit trees, but a timely use of the bran and arsenic mixture described in my report to you for the year 1885 (Report U. S. Department of Agriculture, 1885, p. 300) effectually destroyed them.

Arriving at Merced I interviewed Mr. J. A. Norvell, the editor of the *Merced Express*, and learned from him that but little damage had been done in that locality by locusts the present season. He informed me of a new colony that had been recently started near the foothills, where it was reported the locusts had done considerable damage to the young fruit trees. Accordingly I paid a visit to this colony, and found that about 100 acres of deciduous fruit trees had been either partially or completely defoliated by the locusts; all of these trees had been set out less than a year ago. The land on which these trees were growing had been previously sown to wheat, and wheat fields were on every side. Prune and pear trees had suffered the most from the ravages of the locusts; peach and fig trees were but little injured, while Eucalyptus

trees were untouched. It was reported to me that the locusts had also injured cabbages, tomatoes, and alfalfa. I noticed that the rank grass growing in wet places adjacent to the defoliated trees gave no evidence of having been attacked by the locusts, nor did I see any of them upon it. In the trees I found a few specimens of adults of the Devastating Locust (*Melanoplus devastator* Scudd.), but did not find any of their larvæ or pupæ. I was informed that nothing had been done to destroy the locusts or to protect the trees and plants from their ravages, except by the use of barnyard fowls, or by occasionally driving the locusts out of the trees and killing them with shovels or other instruments.

I also visited the Buhach plantation, where the locusts were so abundant in the year 1885, but learned from the foreman, Mr. Davis, that they had not appeared in large numbers the present season, and what few had appeared were destroyed by the use of the bran and arsenic mixture above referred to. A drive over this and neighboring ranches failed to disclose any injury to trees or plants that had been occasioned by locusts the present season.

From Merced I proceeded to Sacramento, and on the way, after crossing the Merced River near Livingston, we encountered quite large flocks of the Yellow Locust (*Trimerotropis pseudofasciata* Scudd.); and this continued, but in smaller numbers, until we reached the Tuolumne River near Modesto. Next to the Devastating Locust, this species was the most abundant in Merced County in the summer of 1885, and was especially injurious to the leaves of grapevines and small trees. In the present locality are immense grain-fields stretching away as far as the eye can reach, dotted here and there with a farm house surrounded by a few trees and grapevines; still I could not discover that any of these trees or vines had been injured by the locusts.

Arriving at Sacramento, I interviewed Mr. McClatchie, one of the editors of the *Sacramento Bee*, and learned from him that the locusts were very numerous in the eastern portion of Sacramento County. Accordingly I went out to Folsom, where I spent three days investigating this subject. In the town of Folsom very little damage had been done by the locusts the present season; in fact, I saw only one orchard that gave evidence of having been visited by them. To the northeast of Folsom are large vineyards and several orchards of deciduous fruit trees, but none of these gave any evidence of having been attacked to any great extent by locusts the present season, nor could I learn that the locusts had been there in large numbers.

These vineyards and orchards are located in the foothills and are surrounded on every side by trees and small bushes.

I went as far eastward as Shingle Springs, in Eldorado County, but could not learn that the locusts had been very numerous the present season in any portion of this county. West of Folsom are several hundred acres of vineyard and orchards that had been attacked by the locusts the present season, and in one of the vineyards I found the De-

vastating Locusts still present in immense numbers; but very few vines had been completely defoliated by them, and the green grapes were almost untouched, although large patches of the green bark had been gnawed from the vines by the locusts. The foreman of this vineyard informed me that he had not used the bran and arsenic mixture for fear of injuring the sale of the table grapes; but it seems to me that there need be no fear on this account, since the sugar or molasses used in making this mixture causes the arsenic to adhere to the bran, the whole forming a compact mass which is not easily blown about by the wind. I noticed that the oak and pine trees growing in the immediate vicinity of this vineyard had not been attacked to any great extent by the locusts, and in a piece of weeds adjoining this vineyard on the west I found very few adults and no young of the Devasting Locust. The weeds along the sides of the roads in this vineyard had been burned off when the young locusts were first noticed for the purpose of destroying those that had hatched out in such places, but during my visit to the vineyard on the 3d of August I found several young of the Devasting Locust on the grape vines growing next to the roads, indicating that the burning process had not been entirely effectual.

In the more central portion of this vineyard, away from the roads, I did not find any of these young locusts, nor did I find in such places any other kind than the Devastating Locust. I was informed that these locusts came into the vineyard from all directions, while higher up in the air could occasionally be seen swarms of locusts, presumably of this same species, which were going westward.

Among deciduous fruit trees, cherry trees appear to have suffered most from the attacks of the locusts, which had not only completely defoliated them but had also eaten out the dormant buds. Pear trees had also been completely defoliated, while apple, quince, apricot, prune, and plum trees had shared a similar fate, but the green pears, quinces, and prunes escaped uninjured. On the apricot trees large patches of green bark had been gnawed away by the locusts, and the twigs thus girdled nearly always died. Young peach trees had been defoliated by the locusts, but the leaves of the older trees appeared to be distasteful to them, as it was very rare to see a peach tree over 6 feet high that had been completely stripped. On such trees it was no uncommon thing to find that every green peach had been eaten, nothing but the bare pits being left, these sometimes still clinging to the trees, but more often lying upon the ground beneath them. Orange and walnut trees and English Holly were completely defoliated; pine and cypress trees were slightly eaten. I saw several California palms (*Washingtonia filifera*) that had been considerably eaten by the locusts. Egyptian corn growing in the immediate vicinity of trees that had been defoliated by the locusts escaped untouched, and this was also the case with several mulberry trees, although it was reported that the locusts fed upon the fruit of this tree. Fig trees also were but little

attacked by the locusts, although rarely in the case of young trees not only the leaves but also the ends of the green branches were devoured by them. I saw a row of fig trees almost surrounding an orchard of deciduous fruit trees, and while the latter had been nearly defoliated by the locusts the fig trees were almost untouched. It was also reported to me that the locusts would not attack the figs upon the trees.

The above-mentioned orchard and vineyard were nearly surrounded by wheat fields and pastures, while but a few miles east of them and separated by a range of wooded hills is a number of small vineyards and orchards that had not been touched by the locusts. These latter vineyards and orchards were surrounded on all sides by woods. Thus it appeared that orchards and vineyards located in the vicinity of grain fields suffered more from the attack of the Devastating Locusts than did those situated in the woods; and this observation was frequently verified during the remainder of my investigations into this subject. There appears to be something about a grain field that is very attractive to the locusts while they are on the wing high in the air; it may be the bright glistening of the sun upon the yellow straw that attracts their eyes. At one place in San Joaquin County the road had been covered with straw for a distance of several hundred yards, and in driving over this in the middle of the day I noticed that hundreds of the Devastating Locust were resting upon the straw, but none, or only a very few were to be found upon the bare ground near it. I was informed by several persons who had witnessed the coming of these locusts that the large swarms would always alight in a grain field, and from this point they spread in all directions to the adjacent orchards and vineyards. My own observations confirmed this fact, since in nearly every instance the trees around the edges of an orchard had been injured to a greater extent by the locusts than had those in the more central portion. In several instances I saw small orchards which were located only a few yards from the breeding grounds of the Devastating Locust, but separated from them by trees and small bushes, and yet the trees in such orchards had scarcely been attacked by the locusts, while orchards located 30 miles distant, but surrounded by wheat fields, had been almost completely defoliated by locusts which had evidently hatched out in the breeding grounds referred to.

From Folsom I returned to Sacramento and interviewed Hon. Edwin F. Smith, the Secretary of the California State Agricultural Society, and from him I learned that the locusts were very numerous in certain portions of San Joaquin County. I therefore proceeded at once to Lodi, where I met Dr. E. Armstrong, a prominent orchardist of that region, who gave me a great deal of information upon this subject, and also showed me over that portion of San Joaquin County that had suffered most from the attacks of the locusts. Here the conditions were practically the same as I had found them existing in Sacramento County. The orchards which had suffered most were surrounded by

wheat fields; the locusts were reported to have come into them from all directions, while others high in air were moving to the westward. Almond trees had been almost completely defoliated; in many instances the outer part of the nuts had been devoured, and more rarely the hard shell of the three-fourths grown nuts had been eaten through and the kernels devoured. A few large peach trees were scattered through the almond orchard, but these had scarcely been attacked by the locusts. Pear trees had been completely, and locust trees nearly, defoliated by them.

I went as far eastward as Valley Springs, in Calaveras County, but did not find any other locality where the locusts had been unusually abundant and destructive the present season.

From Lodi I went to Marysville and interviewed Mr. G. W. Harney, President of the Yuba County Board of Horticulture, and learned from him that the locusts had been quite destructive to some young fruit trees and grapevines in the southern part of that county. Accordingly, in company with Mr. Harney I visited the locality referred to, and found that the trees and vines had been planted out less than a year ago; many of them bore evidence of having been attacked, but only a very few of them had been completely defoliated. Mr. Harney informed me that when the locusts first began to appear in destructive numbers he had several hundred circulars printed, giving directions for making and applying the bran and arsenic mixture above referred to, and these circulars he distributed to nearly all of the fruit growers in the county; as a result, this mixture was largely used in those localities where the locusts made their appearance in destructive numbers, and proved very effectual in destroying them. We visited portions of the county, distant about 15 miles from Marysville, but did not find any other locality that had suffered from locust attacks.

The following day was spent in visiting various portions of Sutter County, in company with Mr. R. C. Kells, the president, and Hon. H. P. Stabler, the Secretary of the Sutter County Board of Horticulture; Mr. Cutts, a prominent business man of Marysville, and owner of a large orchard in Sutter County, also accompanied us. We visited a large portion of the northeastern part of this county, but found only one locality where the locusts had appeared in destructive numbers the present season. This was in an orchard of deciduous fruit trees, several of which bore evidence of having been attacked, although none of the trees had been completely defoliated. The owner informed me that he had made use of the bran and arsenic mixture and this had effectually destroyed the locusts before they had materially injured his trees. The next day, in company with Mr. G. W. Harney, I visited portions of Butte County, in the vicinity of Oroville. I did not see any indication of locust attack in this city, nor could I learn that the locusts had appeared there in destructive numbers the present season. A few miles west of Oroville several small orchards had been

planted out less than a year ago, and a few acres of these trees had been completely defoliated by the locusts. I learned that when the latter appeared upon the trees nothing whatever was done to stop their ravages. They had also appeared in large numbers upon the young trees in the adjoining orchards, but had been destroyed by the bran and arsenic mixture that had been put out when the locusts first made their appearance. We also visited a certain locality about 8 miles south of Oroville, where a large tract of land had recently been set out to fruit trees; here but little damage had been occasioned by locusts.

From Oroville I went by stage to Biggs, in the southwestern part of Butte County; the country passed through was mostly bare pasture lands, where very few locusts of any kind were seen. From Biggs I took the train to Redding, in Shasta County, and interviewed several persons there; from them I learned that locusts had not appeared in large numbers in that locality the present year, nor could I learn that they had been at all numerous in this State north of Redding. I learned, however, that several small orchards in the vicinity of Cottonwood, in the southern part of Shasta County, had suffered from the attacks of locusts. Accordingly I returned to Cottonwood and spent the greater portion of a day in that vicinity, and found that the injury to the orchards occasioned by locusts was slight, there being but few orchards in that locality and these very small ones. This completed my observations in the field, and I returned to Los Angeles by way of San Francisco. At the latter place I visited the Academy of Natural Sciences and obtained the names of the birds and plants referred to in the subsequent pages of this report.

As was the case in the year 1885, the species of locust that had produced the greatest amount of injury the present season is the Devastating or California Locust (*Melanoplus devastator* Scudd.). These always have a small blunt spine in the middle of the breast between the front legs, and the hind or under wings are wholly hyaline or glassy. The colors vary to a considerable degree; in normally marked individuals the ground color is dark gray, and there is a blackish stripe along each side of the thorax, several black spots on the front wings, and a series of black marks on the hind thighs, but in a few individuals the ground color is a very pale yellowish, and the black markings above referred to are very indistinct or are sometimes entirely wanting. These pale individuals belonged to both sexes and are doubtless immature specimens, which later in the season will acquire the normal black markings of the other and more mature form. I submitted specimens of these pale-colored individuals to Professor Riley, who wrote me that they belonged to *Melanoplus devastator*, and he also referred the darkly marked specimens to the same species. Both of these forms have the hind tibiæ, or shins, of a bluish color, but I found associated with them, both in the breeding grounds and also among those that had migrated to the orchards and vineyards, a form which resembled them in colors

and markings, except that the hind tibiæ were of a light reddish color. All the specimens that I captured of this red-legged form are females, and Professor Riley writes me that he is unable without the male to decide to what species they belong. I strongly suspect that they simply constitute a color variety of *Melanoplus devastator*, since such varieties are known to occur among several of the species of this genus found east of the Rocky Mountains. These three forms, which, as above stated, probably belong to one and the same species, were the only spine-breasted locusts with long wings that I met with during my investigations. I also found two or three species of spine-breasted locusts with short wings, belonging to the genus Pezotettix; but these were mostly found in the dry pastures, and only in limited numbers.

Among the spineless-breasted locusts, the species I met with the most often is the Red-winged Locust (*Œdipoda venusta* Stal.); this I found in almost every locality visited, but never in large numbers. The next most abundant species, and one of the largest found in this State, is the *Dissosteira spurcata* of Scudder; this is more local in its distribution than the preceding species, and is usually found in dry pasture lands, sometimes occurring in quite large numbers. The male of this species is much darker colored than the female, and has a curious habit of hovering in the air for several minutes at a distance of 16 or 18 inches above the female.

The Pellucid-winged Locust (*Camnula pellucida* Scudd., of which *Œdipoda atrox* Scudd. is a synonym), which was reported as being very destructive during several successive years in the past in Sierra Valley, lying partly in Sierra and partly in Pimas counties, in the very heart of the Sierra Nevada Mountains, I met with at only one place; this was on an open hillside in Calaveras County, August 8, but they were not at all abundant, and I saw only about two dozen specimens in an hour's search. I dissected several of the females, and the ovaries contained nearly fully formed eggs. Several other species of spineless-breasted locusts were also met with, but these were so few in number that no further mention of them need be made at the present time.

BREEDING GROUNDS OF THE DEVASTATING LOCUST.

Up to the present time but little seems to be known concerning the early stages of the Devastating Locust. I have not been able to find any published notice stating that any observer had seen these locusts paired, or had observed the females laying their eggs, or had found the eggs of this species. During the present investigation I paid especial attention to this part of the subject. Although repeatedly sought for, I never found any of the young of this species in the more central portion of cultivated orchards and vineyards, nor in grain fields that had been plowed and seeded less than a year previously. I also did not find them in thickly wooded land where there was an abundance of small trees and bushes, nor upon the tops or the steep sides of high hills,

nor yet in the low wet grass lands. In the San Joaquin and Sacramento valleys and among the foothills bordering them on the east it was only upon land on which grew a certain kind of weed that I found the young of this locust. I submitted specimens of this weed to Mrs. Dr. Brandegee, the Botanist of the California Academy of Sciences and our best authority upon the plants of central and northern California, and she identified it as the *Hemizonia virgata*, vulgarly known as "tarweed," from the sticky exudations which cover the entire plant. It seldom attains a greater height than 2 feet, the stem is slender, and sometimes bears several small lateral branches, the leaves are small, narrow, and dark green, and the greater portion of the stem is of a whitish, somewhat silvery color. It bears at the tips of its branches yellowish composite flowers, which seldom exceed half an inch in diameter; the leaves on the upper portion do not exceed a quarter of an inch in length. The plant is said by Dr. Asa Gray to be either an annual or a biennial.

In the eastern portion of San Joaquin and Sacramento counties and also in portions of Calaveras and Eldorado counties that I visited, it was rare to find a patch of these weeds in which the young of the Devastating Locust were not present in greater or less numbers; at the same time it was extremely rare to find the young of these locusts in places where none of these weeds grew. I found both these weeds and the young locusts along the sides of the roads, and also upon unplowed land about the orchards and vineyards. They were also sometimes present in fields of volunteer or self-sown grain that had not been plowed for over a year, but were most abundant in the pasture lands among the foothills. Here they usually occurred in the narrow valleys or depressions lying between the hills, sometimes extending some distance up the sides of the hills, but never high up on the sides of very steep hills, nor on the tops of hills, nor yet among the thick underbrush wherever this might occur. Among the foothills of Calaveras County, in the neighborhood of the town of Burson, I found a field of these weeds covering 60 or 80 acres of land, and among the weeds were both adults and young of the Devastating Locust in large numbers. I was informed by a party living in the neighborhood of this field that the young locusts had been extremely abundant there early in the season, and that in the month of May he saw a large swarm of the winged locusts take flight and disappear to the westward; it was reported to me that about this time the locusts were first observed to come into the orchards in certain portions of San Joaquin County, lying in the same direction that the swarm was said to have taken; so it appears quite certain that the large swarms of locusts that swept down upon the above-named county the present season hatched out in this and neighboring fields of tarweeds.

I dissected a large number of the adult females of the Devastating Locust which I found in this field and examined the ovaries, but in none of them did I find any eggs in an advanced stage of development,

nor did I see any of these locusts paired, nor were any engaged in laying their eggs. On the 10th of August, accompanied by Mr. F. V. M. Hudson, of Acampo, and one of his hired men, I spent the greater portion of the day in searching for the eggs of this locust in the above-mentioned and neighboring fields of tarweeds, but did not succeed in obtaining any. This fact, coupled with the further fact thât while studying this and other species of locusts in Merced County in the year 1885 I neither saw the Devastating Locusts paired nor did I observe them laying their eggs during all the time that I observed them, extending from the first week in June to the first week in August, and that I did not witness either of these operations during the present investigation which extended over the first three weeks in August, makes it almost certain that this species is single brooded and that the eggs are laid some time during the fall of the year, probably not before the month of October. All the testimony goes to prove that these locusts hatch out very early in the spring. Several intelligent observers informed me that they had seen the young locusts in immense numbers early in April and that these began to acquire wings early in May. The following from the *Folsom Weekly Telegraph* of May 9, 1891, indicates how early in the year these locusts appeared in that locality the present season:

GRASSHOPPERS COMING.

Grasshoppers have appeared in the vicinity of this place. They seemed to come suddenly and from where no one knows. Millions of them are destroying everything they can get hold of, and considerable alarm is felt over their appearance and the result of their visit. They came too late to do any great amount of damage to the hay crop, which is nearly all in. Other things will surely suffer unless they disappear. Those that are here are, from what we can learn, very small, but they are voracious and have done a great deal of damage already. A few years ago they visited the State and caused great damage. There was no way to combat them. We hope the alarming reports regarding them are exaggerated.

The editor of the "Telegraph" informed me that he sent the above as a telegram to the *Sacramento Bee* on the 5th of May, which would put the coming of the locusts at a somewhat earlier date than the one given above.

Hatching out so early in the season and acquiring wings as early as the month of May, it appears somewhat singular that these locusts should not become fully matured and deposit their eggs until nearly six months later in the season. The fact, however, that among the migrating swarms I found very pale-colored specimens that had not yet become sufficiently mature to attain their normal dark coloring as late as the middle of August, indicates that the species is very slow in maturing even after acquiring wings. The destructive Rocky Mountain Locust (*Melanoplus spretus* Uhler), which has as yet never been found in this State, is known to be single brooded in its permanent breeding grounds.

In Los Angeles County, on the 20th of September of the present year, I saw a pair of Devastating Locusts united in coition; this was the only pair I saw in a five-hours' search in a locality where these locusts were quite abundant. I find by reference to my note book that on the 1st of October, 1888, I also saw a pair of locusts belonging to a closely related, but apparently unnamed species united in coition.

On page 21 of INSECT LIFE, Vol. IV, Mr. Lawrence Bruner, one of the agents of this Division, in referring to the Devastating Locust, says: "This species also occurs in two forms, viz, small and large, being the spring and fall broods, as nearly as I have been able to decide from specimens in collections." This supposition, however, is not borne out by the facts, since in the month of August of the present year I collected both large and small specimens of this species in Sacramento County; the smallest specimens measured only 16 millimeters (about three-fifths of an inch) from front of head to tip of abdomen, while the larger specimens, which were captured in the same locality as the smaller ones, measured 25 millimeters (equal to 1 inch) in length. Specimens representing both sizes, as well as others of every intermediate grade, were submitted to Professor Riley, who referred all of them to the above species, so there can be no doubt of ther proper identification.

All the facts therefore seem to indicate that the Devastating Locust is normally single-brooded, and that the eggs are laid in the fall of the year.

Although I saw both the adults and the young of the Devastating Locusts feeding upon the tarweeds in the large field near Burson, referred to above, still they had not completely devoured these weeds, which were still green and growing. Immediately adjoining this field on the west was about half an acre of plants of *Hosackia glabra* that had been completely defoliated, presumably by these locusts; I did not find any young of the Devastating Locust among these defoliated plants. These were the only wild plants I saw that there was reason to believe had been completely defoliated by these locusts.

North of Sacramento I did not again meet with this tarweed; but in Yuba, Butte, and Tehama counties it is replaced by a viscid, glandular plant, which Mrs. Brandegee identified as *Layia glandulosa.* This is a low growing, loosely branched annual, which never exceeds a foot in height; the leaves are narrow, and the composite flowers are white, with a dark yellow center; the entire plant bears numerous short, stiff hairs.

I found this plant growing on the sides of low hills or on the high mesa land, and when found in large numbers it was nearly always accompanied by the young as well as by the adults of the Devastating Locust; and in the above-named region I did not find any of the young of this locust except in places where this weed grew.

One of the most common weeds I met with growing in the dry pasture lands and in the open foothill region in the eastern part of the San

Joaquin and Sacramento Valleys, extending from Tehama County on the north to Merced County on the south, is a low-growing, much-branched, pubescent, whitish plant, which Mrs. Brandegee informs me is *Eremocarpus setigerus*, sometimes known as "turkey-feed," owing to the fact that the turkeys are very fond of it. This plant was present in almost every locality that I visited, but I did not see any of the Devastating Locusts feeding upon it, nor were the young of this locust ever found upon these plants, nor among them except when the latter grew in the vicinity of one or the other of the two plants referred to above. The "turkey-feed" plants evidently had no attraction for these locusts, which appear to prefer plants of a viscid or sticky nature.

Of course it is possible that, in certain localities which I did not visit, the Devastating Locust may breed among other kinds of weeds than the two referred to above, but the fact that I found the young of this locust in almost every patch of these weeds of any considerable size, taken in connection with the other fact that I very seldom found the young locusts except in places where these weeds grew, makes it almost certain that this locust chooses patches of these weeds in which to breed.

CAUSE OF THE LOCUST RAVAGES.

The region of country in this State that suffered most from the ravages of the Devastating Locust the present season is comprised in the three counties of Placer, Sacramento, and San Joaquin. In certain portions of these counties it was reported by several observers that the locusts came from the eastward in large swarms, not all at once, but in two or three separate swarms at intervals of about two weeks apart. From what has already been written it is almost certain that these large swarms hatched out in the open pasture lands among the foothills in the eastern part of Sacramento County, and also in the western portion of Eldorado, Amador, and Calaveras counties, in places overgrown with tarweeds.

The fact that these locusts do not appear in destructive numbers every season has led some persons to believe that these insects—like the misnamed Seventeen-year Locust of the East (*Cicada septendecim* Linn.)—pass several years in the larva state, but of course such is not at all the case; and if the facts were known it would evidently be found that these locusts migrate to the orchards and vineyards every year, but not always in sufficient numbers to attract attention. It appears to be a settled fact, however, that the years in which they have been present in destructive numbers in the region designated above were in seasons when there had been little or no late rains in the spring and when there had been heavy and long continued rains the previous spring. In other words, it appears that there must be a spring of long-continued and late rains, followed by one in which very little rain falls, in order to produce an unusual number of the locusts. These conditions existed in the years 1884 and 1885, and again in 1890 and 1891,

and we find that the locusts were unusually abundant and destructive in the year 1885 and again in 1891.

To give any rational explanation of this phenomenon would require a greater knowledge of the habits and early stages of this insect than we at present possess. It may be conjectured, however, that the long-continued and late rains retard the hatching of the young locusts, and at the same time produce such an abundance of vegetation that the greater number of the locusts would remain upon the breeding grounds the entire season and would deposit their eggs in these grounds late in the fall; thus a much greater number of eggs would be deposited in the breeding grounds than would have been the case had the season been dry and the majority of the locusts migrated from the breeding grounds before their eggs had been deposited. The following season being a dry one there would not be abundance of vegetation, and the eggs in the breeding grounds would naturally hatch out very early in the spring, and the immense numbers of locusts produced would soon reduce the scanty vegetation to such an extent that they would be very anxious to migrate to new fields as soon as they had acquired wings. And this would account for the immense swarms that occasionally appear in this region, and would also account for the fact of their not occurring every season.

While these locusts have been observed to migrate in swarms from their breeding grounds, no person has ever seen them returning to these grounds again, and it seems very probable that they never do so. The eggs of these migrating swarms are doubtless deposited in cultivated lands, and the subsequent plowing and harrowing of these lands evidently destroys the eggs. Thus the species must depend for its continued existence upon the comparatively few individuals that remain upon the breeding grounds throughout the season, or at least until the egg-laying season has passed by.

Several different persons living in the locust-infested district stated to me that the earlier-migrating swarms of Devastating Locusts had deposited their eggs in the cultivated fields and orchards, and that they had seen the young of these locusts in the above-mentioned places. Questioned closely, they all admitted that they had not seen the locusts in the act of depositing their eggs, nor could they refer me to a single person who had seen them thus engaged; but the fact that they had found what they believed were the young of these locusts in the localities mentioned, led them to believe that the earlier broods had deposited their eggs in such situations. I took especial pains to investigate each of these reports, but found that in not a single instance did the young locusts observed belong to the destructive migrating species. In the majority of cases they belong to the young of the spineless-breasted locusts, but in one instance the adults of one of the short-winged locusts, the *Pezotettix enigma* Scudd, were mistaken for the young of the Devastating Locusts; these short-winged locusts have a

spine in the middle of their breast, between the legs composing the front pair, in this respect resembling the young of the Devastating Locust; and although fully developed their wings do not cover the basal half of the hind body or abdomen, thus giving them the false appearance of being young locusts. From the young of the Devastating Locust they can at once be distinguished by never possessing the conspicuous whitish spot found near the base of the wings; and if the wings are more attentively examined it will be found that in the short-winged *Pezotettix* the nerves of the lower half of each wing extend nearly parallel with the lower margin of the wing, whereas in the young of the Devastating Locust the veins run in an oblique direction to the lower edge of the wings. These characters will enable the most casual observer to distinguish the young of the Devastating Locust from any of the short-winged locusts known to me to occur in this State.

NATURAL ENEMIES.

During my visits to those portions of the State that had suffered most from the attacks of the locusts, I was struck with the almost entire absence of insectivorous birds and insects. Of course every collector of insects in this State is aware of the fact that in the month of August insect life is less abundant in the valleys than it is at almost any other season of the year, and this may also account for the scarcity of insectivorous birds in the valleys during this time of year.

Probably the bird that renders the greatest benefit to our horticulturists in the way of destroying locusts is the Arkansas Kingbird (*Tyrannus verticalis* Say), also known as the Arkansas Fly-catcher, and locally as the Bee-bird from its reputed habit of occasionally feeding upon Honey Bees. Near the town of Clements, in San Joaquin County, I saw a pair of these birds perched in a tall cottonwood tree that grew along the edge of the Mokelumne River. This tree stood some distance from the banks of the river proper, and just back of it, and still farther from the river rose a high bluff, the sides of which were almost perpendicular. At certain intervals the Devastating Locusts would rise from the ground along the bank of the river and proceed to fly over these bluffs, but when nearly opposite the tree upon which the Kingbirds were perched, one of these birds would dart forward, seize the locust, and return to the tree again to devour its victim. During the few moments that I watched this pair they captured quite a large number of the locusts, always returning to the same tree to feed upon them. In the American Naturalist for August, 1869, Mr. Robert Ridgway, the well-known ornithologist, makes the statement that a specimen of this Kingbird, which he kept in a cage, devoured 120 locusts in a single day. Were these birds at all numerous, it is evident that they would destroy immense numbers of the locusts in the course of a single season; but, unfortunately, they were only occasionally seen in any of the localities that I visited.

Another bird that also preys upon locusts is the California Shrike (*Lanius ludovicianus gambeli* Ridg.), locally known as Butcher-bird, from its habit of impaling insects, small birds, lizards, etc., on almost any sharp-pointed, thorn-like object within its reach. At several different places I saw one of these birds fly to the ground, seize a locust, and return to its former perch to feed upon its victim; but frequently it would impale the locust upon some sharp-pointed object and leave it there to die. The sharp barbs of a barbed wire fence were frequently used by these birds for impaling the locusts upon, and in driving along one of these fences it was no uncommon sight to see at short intervals one of the locusts thus impaled. Unlike the Arkansas Kingbird, which invariably captures the locusts while upon the wing, this Shrike appears to attack them only upon the ground. Its habit of impaling them upon sharp-pointed objects would allow of its destroying an almost unlimited number of locusts in a day. Unfortunately, this bird is not abundant in any portion of the locust-infested region.

These two were the only birds that I saw capture and feed upon locusts, but Mr. Walter E. Bryant, the Ornithologist of the California Academy of Sciences, to whom I am indebted for the names of these birds, informs me that he has found locusts in the stomachs of the following California birds: Great Horned Owl (*Bubo virginianus* Gmelin); Burrowing Owl (*Speotyto cunicularia hypogæa* Bonap.); Sparrow Hawk (*Falco sparverius* Linn.); Road-runner (*Geococcyx californianus* Lesson); and Western Lark Finch (*Chondestes grammacus strigatus* Swainson).

While investigating the locust plague in Merced County for the Department in the year 1885, I saw three other birds feeding upon locusts; these were: Bullock's Oriole (*Icterus bullockii* Swainson); California Song-sparrow (*Melospiza fasciata samuelis* Baird), and another undetermined species somewhat larger than the latter, and having a conspicuous patch of red feathers on the crown of the head.

The Burrowing Owl was quite frequently seen, occurring in and about the burrows of the California Ground Squirrel (*Spermophilus grammurus beecheyi* Richardson). These, however, were most abundant in the dry, level plains, where but few locusts occurred. The other birds mentioned above were occasionally met with, but were not at all numerous in the locust-infested regions.

Of the smaller animals, I have seen the Western Fence-lizard (*Sceloporus occidentalis* Baird–Girard) catch and devour locusts. This lizard is commonly known by the name of Swift. This and allied species are quite commonly found all over the locust-infested regions and doubtless destroy a large number of the locusts.

Among predaceous insects, the species which probably destroys the greater number of locusts, and the one most frequently met with, is a medium-sized, wholly black wasp known as *Priononyx atrata* St. Farg. This wasp digs its burrow in the earth, usually in loose sandy soil, and

provisions it with locusts which she catches while on the wing and stupefies them by repeatedly thrusting her sting into their bodies, the point selected for thus stinging them being in nearly every instance the underside of the thorax between the first two pairs of legs. After being stung a few times the locust becomes motionless, and the wasp gets astride of her victim, seizes it by the antennæ, and drags it to her burrow, occasionally leaving it and going off in search of her burrow; after finding it she again returns to the locust and drags it along by the antennæ as before. After it is safely landed in the bottom of the burrow, the wasp deposits one or more eggs upon it, then comes to the mouth of the burrow and with her fore feet scratches the burrow full of earth, somewhat as a dog would do. All of her movements are very rapid, and it is very rare to find her idle, being almost the whole time, at least during the warmer portion of the day, engaged in searching for or dragging along and burying the locusts. I frequently saw one of these wasps thus dragging along a locust, and although other species of locusts were present she always selected a Devastating Locust for her victim.

I also saw another kind of wasp, known as *Polistes variatus* Cresson, feeding upon a recently killed Devastating Locust, while several other specimens of the same kind of wasp were busily looking among the weeds, as if in search of locusts. This wasp is of about the same size as the Priononyx, referred to above, but is of a light-brown color, variously marked with pale yellow. I have occasionally found the nest of this wasp beneath pieces of wood lying upon the ground. The nest is constructed of a bluish gray, papery substance, is of a circular form, and measures about 2 inches in diameter. It is suspended by a rather slender pedicel of the same papery substance, and the cells are on the underside and open downwards; they are filled with a yellowish mass, which probably consists of the masticated bodies of the locusts.

Besides these two species, I have seen a third kind of wasp, the *Tachytes rufofasciata* Cr., dragging along an apparently lifeless locust, which she evidently intended to bury, to serve as food for her young, just as the Priononyx described above was observed to do. This wasp is considerably smaller than the Priononyx, and has the abdomen and a large portion of the legs pale brown.

Besides these wasps, the only other kind of predaceous insect that I saw feeding upon locusts is a large slender-bodied, two-winged fly, known as *Proctacanthus milbertii* Macq. This fly is of a brownish gray or drab color, and the largest specimens measure nearly 1½ inches in length; the legs are stout and covered with spines; the stout, black proboscis projects forward from the lower portion of the head, and the latter on the sides and lower part in front is thickly clothed with rather long whitish hairs. Riding along by the side of a barbed-wire fence in Tehama County, on the 15th of August, I saw a great many of these flies resting upon the upper side of the top wire, while an occasional

one was seen hanging from the under side of the wire, to which it was clinging by the aid of its strong claws, while between its body and the wire, and firmly held in its embrace, was an adult locust, into whose body the proboscis of the fly was inserted. The fly was not particular as to the kind of locust it captured, sometimes catching and feeding upon the Devastating Locust, at other times attacking an undetermined species of spineless-breasted locust. When not feeding, these flies were very shy, taking wing whenever approached at all closely, but when engaged in feeding I had no difficulty in capturing them in my hand. On the same day above mentioned I saw several of these flies paired, but I know nothing in regard to their early stages. Professor Riley has recorded the fact that the larvæ of an allied species, the *Erax bastardi* Macq., feed upon the eggs of locusts, and it is very probable that the larvæ of the present species has the same commendable habit.

Of internal parasites I know of only one species that attacks locusts; this is a grayish black, two-winged fly which closely resembles the common House Fly but belongs to a different family, the Sarcophagidæ, and to the typical genus Sarcophaga; the thorax is marked with three blackish, longitudinal lines, and the abdomen is marmorate with darker spots which are changeable in different lights. I first met with specimens of this fly on the 15th of August in Tehama County; the locality was a small tract of land covered with low-growing weeds, among which were quite a large number of locusts of different kinds. The flies were resting upon dead weeds, stones, etc., and whenever a locust of any kind took to its wings one of these flies would dart after, and appear to strike it, but this was evidently the method in which the fly attaches her eggs to the bodies of the locusts. When thus struck by one of the flies the locust in nearly every instance would at once close up its wings and fall to the ground, as if aware of danger. I did not succeed in breeding the perfect flies from these locusts, but among a large number of insects sent me for names by Mr. E. M. Ehrhorn, of Mountain View, was a single specimen of the same kind of fly which he informed me was received with several others from a Placer County correspondent; the locust which he pointed out to me as being the one from which this fly was bred belongs to the destructive California species, *Melanoplus devastator* Scudd. While at Marysville, Mr. G. W. Harney, the President of the Yuba County Board of Horticulture, showed me a Dipterous pupa which he had bred from one of our largest spineless-breasted locusts, *Dissosteira spurcata* Stal.; but as the fly never issued from this pupa the species to which the latter belongs can not be ascertained, although it is very probable that it belongs to the same species referred to above.

In Merced County, in the summer of 1885, I collected quite a large number of specimens of this same kind of locust, inclosing them in a bottle containing potassium cyanide, and from one of these issued a Dipterous larva, which, however, was not observed until it had been killed by the fumes of the cyanide, so that the species to which it belonged could not be ascertained.

These Dipterous parasites appear to be extremely rare. In every locality visited I dissected large numbers of locusts belonging to various species, but did not find any of them to contain a trace of these parasites. I also brought a large number of the locusts home with me, but up to the present date no parasites have issued from them.

Quite a large number of locusts were infested with small red mites, presumably *Trombidium locustarum* Riley, but these did not occur in numbers sufficient to prove fatal to the locusts they infested.

On page 263 of the Second Report of the United States Entomological Commission, Professor Riley records having bred two different kinds of Bee-flies from larvæ found feeding upon the eggs of locusts in Sierra Valley, California, the two species being *Aphœbantus mus* O. S. (of which *Triodites mus* is a synonym) and *Systœchus oreus* O. S.; but, although I was especially on the lookout for specimens of these two species, I saw only a single specimen of the Aphœbantus. This was in Tehama County, and the specimen was resting upon the doorstep of a dwelling house. During the entire three weeks that I spent in investigating the locusts, the greater part of this time having been spent in the fields, I did not see another specimen of this species, nor of any other species belonging to this or to closely related genera. The Bee-flies that I saw belong to the genera Toxophora, Geron, Anthrax, Argyramœba, and Exoprosopa, none of which in the larva state are known to feed upon the eggs of locusts nor to attack the locusts themselves. Here in southern California I have collected specimens belonging to twenty-two different species of Aphœbantus, several of which occur in quite large numbers; and it is evidently largely due to the presence of these insects that the locusts so seldom occur in destructive numbers in this part of the State.

In the first report of the United States Entomological Commission, pages 297 to 301, Professor Riley gives an extended account of the early stages of three different species of Blister-beetles, the larvæ of which he found feeding upon the eggs of various kinds of locusts in the region of country lying east of the Rocky Mountains. These beetles belong to two genera, Macrobasis and Epicauta, but neither of the three species referred to are found in California. So far as I am aware the genus Macrobasis is not represented in this State, but of Epicauta and related genera my collection contains representatives of nearly two dozen species found in this State, but principally in the southern portion of it. During my recent investigating trip I met with only one kind of Blister-beetle, the *Epicauta puncticollis* Mann., a slender, wholly black species, which, however, was not abundant in any of the localities visited. They were most abundant in the neighborhood of Oroville, in Butte County, where I found them feeding upon a low-growing weed, *Layia glandulosa*, already referred to in the chapter treating upon the breeding grounds of the locusts. Since the Devastating Locusts had bred in the same locality, as was evidenced by my finding the young of

these locusts among the weeds also infested by the Blister-beetles, it is very probable that the latter while in the larva state had fed upon the eggs of the locusts. This supposition appears to be rendered all the more probable by the further fact that in the immediate vicinity of these beetles the locusts did not occur in large numbers, nor had the orchards and vineyards in this locality been seriously injured by them. The fact recorded above that the larvæ of other species of Blister-beetles belonging to the same genus are known to feed upon the eggs of locusts renders it almost certain that the present species while in the larva state also feeds upon the eggs of these insects, and would, if sufficiently plentiful, keep the locusts so reduced in numbers that it would be impossible for them to become numerous enough to occasion any widespread injury to cultivated trees and plants. Unfortunately there appears to be no method whereby we can secure the more rapid propagation of these and the other natural enemies of the locusts, and our only recourse therefore is to subdue these pests by artificial means.

REMEDIES.

I have already stated the fact that when the locusts appeared in ordinary numbers they were effectually destroyed by the use of the bran and arsenic mixture, composed of the following ingredients in the proportions here given:

	Pounds.
Bran	100
Arsenic	16
Sugar	16
Water sufficient to thoroughly wet the mixture.	

The bran is placed in any convenient receptacle, and the arsenic added to it dry; the two are then thoroughly mixed together with a shovel, spade, or other instrument. The sugar is then dissolved in cold water and afterwards added to the bran and arsenic mixture and the whole thoroughly stirred; if this is not sufficient to wet the mixture, enough cold water should be added to accomplish this, and after being thoroughly stirred, the mixture is ready for use. In applying it, some persons sow it broadcast by hand in the orchards and vineyards, while others simply drop about a teaspoonful of the mixture at the base of each vine or tree. By the latter method about 10 pounds of the bran and 1⅝ pounds each of sugar and arsenic will be required for each acre of grapevines. The cost of the materials and of the labor in preparing and applying this mixture will not much exceed 50 cents per acre of grapevines, while in the orchards the cost will be much lower than this.

The addition of the sugar is simply for the purpose of causing the arsenic to adhere to the particles of bran, and not for the purpose of rendering the mixture more attractive to the locusts, since I ascertained

by experiments that the bran is much more attractive to the locusts than sugar is. Some persons informed me that they had used molasses in place of the sugar, and with equally good results. A few had added a quantity of glycerin to the mixture in order to prevent it from drying out and forming a solid mass that the locusts can not readily feed upon, but it is doubtful if this is any great improvement over the ordinary way.

I met several persons who reported that they had not obtained satisfactory results by the use of this mixture, but I learned from them that they had used only 2 pounds of arsenic to 100 pounds of bran; this, of course, would make a very weak mixture, containing only one-eighth as much arsenic as it should have contained, and therefore it is not to be wondered at that it did not produce the same results as the stronger mixture would have done. The arsenic in this mixture is very slow in its actions upon the locusts. I have seen locusts feeding upon it quite early in the morning, and these were still alive in the evening, but died during the night.

There has been some objection made to the use of this mixture on account of the danger attending its use, but with only ordinary precautions no danger need be apprehended from it. Although it has been quite extensively used in various parts of this State during the last six years, still I have not learned of a single instance where human beings or domestic animals of any kind have been poisoned by it. It is advisable to prepare the mixture in a closed room in order to prevent the arsenic from being blown about by the wind, but after the mixture has once been thoroughly saturated with water there is no danger of its being blown about, nor is there any great danger of its being carried about upon the feet of birds or insects. Of course it should never be placed within the reach of poultry or of domestic animals of any kind; these, however, are seldom allowed to run in the orchards or vineyards, so that little or no additional trouble would result from the use of the poisoned mixture in such places.

Several persons informed me that they had sprayed their trees with Paris green and water at the rate of 1 pound of this poison to about 200 gallons of water, but this did not deter the locusts from feeding upon the leaves of the trees thus sprayed; nor could it be discovered that any of the locusts had been destroyed by feeding upon the poisoned leaves. This is scarcely to be wondered at, since it would not be possible in this manner to cause a sufficient quantity of the poison to adhere to the leaves without at the same time severely injuring the latter. A far better plan is to use the bran and arsenic mixture described above, as there is no danger of injuring the trees by its use.

I was also informed that trees had been sprayed with various substances to deter the locusts from feeding upon them, but all that I conversed with upon this subject reported unsatisfactory results. The following from the *Folsom Weekly Telegraph* of August 1, 1891, would

seem to indicate that at least one person had obtained good results in this direction:

A WAY TO FIGHT GRASSHOPPERS.

EDITOR TELEGRAPH: While on business at Capt. Russell's ranch, about 5 miles northeast of this place, in Placer County, I found his fine orchard and vineyard all safe from the ravages of the grasshopper pests, although they have played sad havoc with other orchards near by. Upon inquiry of the Captain I was informed that he had used a remedy that did not suit the tastes of the hoppers, and therefore they chose other localities in which to locate. He used the following preparation: One pound of aloes to 5 gallons of water. Dissolve well in warm water, and then spray with a fine spray pump. A simple taste of this liquid seems to discourage the operator and he moves to other quarters. Capt. Russell thinks that his discovery is good when well applied. I give this information for what it is worth, and hope some good may be derived from it. The condition of Capt. Russell's orchard justifies the confidence he expresses in the remedy mentioned.

G. S. TONG.

FOLSOM, CAL., *July 28, 1891.*

The fact that the locusts feed upon such a great variety of trees and plants, including such offensive ones as tarweeds and Conifers, which most other leaf-eating insects pass by, would seem to indicate that it would be extremely difficult to find a substance so disagreeable and offensive to the locusts that they would not feed upon the leaves of plants sprinkled with it. It is possible that blood obtained from the slaughterhouses might answer this purpose, since it has been found that rabbits will not feed upon the bark of trees on which blood had been rubbed.

Quite a number of persons employed turkeys for the purpose of freeing their orchards and vineyards of the locusts, and I learn from one of the members of a certain firm in San Joaquin County that they employed a flock of 766 turkeys in their orchard, which contains about 800 acres of fruit trees of various kinds. One turkey will destroy an almost incredible number of locusts in a single day, and a flock of the size of the one above described must necessarily destroy large numbers of the pests in the course of an entire season. I was informed of several instances where turkeys had eaten too freely of the locusts, having partaken of them to such an extent as to result in the death of the turkeys, but it was asserted that this never happened if the turkeys had been fed grain before being turned into the orchard in the morning. Several persons objected to having the turkeys in their orchards owing to a fondness which these birds develop for ripe fruit, as it was found that when the turkeys once took to feeding upon the fruit they forgot all about the locusts and proved quite as great a pest as did the insects which they were expected to annihilate, rather than to aid, in their destructive work. Owing to this undesirable habit of the turkey it would be advisable to allow them the freedom only of nonbearing orchards and vineyards, or at least, of those not containing ripe or nearly ripe fruit.

Besides turkeys, the common barnyard fowls also prove to be very efficient destroyers of locusts. This fact was abundantly attested in the case of an almond orchard containing about 360 acres; this orchard had been attacked by the migrating swarms which had spread over the greater portion of it. The house, barn, and other buildings were situated nearly in the center of this orchard, and the barnyard fowls had been allowed to range among the trees immediately surrounding them; these trees covered perhaps 6 or 8 acres of land, and, at the time of my visit to this place on the 7th of August, presented a very different appearance from those in the remaining portion of the orchard, reminding one somewhat of an oasis in the desert. All about them the trees had been nearly stripped of their leaves by the voracious locusts, while upon those growing in the area designated above but few of the leaves upon the trees had been eaten, owing to the persistent attacks of the barnyard fowls upon the invading locusts.

In some localities the practice of driving the locusts out of the orchard was resorted to, and resulted in some cases in a fair degree of success. To accomplish this a band of men armed with clubs, shovels, etc., started in at the eastern side of the orchard, and forming a continuous line north and south, proceeded to drive the locusts before them, driving them from tree to tree until they were driven completely out of the orchard. It was stated that after the locusts had been driven a certain distance they refused to go any farther, as if too tired, but after being allowed to rest for a short time they then permitted themselves to be driven before the advancing line of men. This driving was repeated six or seven times at short intervals, and in the majority of cases resulted in preventing the locusts from defoliating the trees.

Some persons employed a somewhat different method of driving the locusts out of their orchards. A small pile of dry straw was placed on the west side of each tree in the orchard, and a small quantity of sulphur thrown upon each pile; the most eastern piles of straw were first ignited, and the wind, blowing from the west, blew the sulphur smoke through the trees standing to the eastward of the burning straw; this caused the locusts to fly out of these trees, and as they always go almost straight against the wind, they would fly to the trees in the rows west of those they were smoked out of. The next row of straw piles was then set on fire, and this process was continued until the locusts had been driven entirely out of the orchard. In conversation with several persons who had tried this method I was informed that it resulted in a fair degree of success, while several others, who had also tried it, informed me that it was a complete failure, and that the locusts paid no heed whatever to the sulphur smoke.

The practice of driving the locusts out of one orchard into another can hardly be approved upon general principles, as it is hardly fair for any man to drive the pests out of his own orchard into that of a neighbor.

In the opening paragraph of the present chapter occurs the state-

ment that the locusts could be effectually destroyed by the use of the bran and arsenic mixture when they occurred in ordinary numbers, but I was informed that where they came in large swarms this mixture scarcely produced any appreciable effect in lessening their numbers, dozens of individuals coming to take the place of each of their fallen comrades, and these new comers succeeded in almost completely defoliating the trees in spite of the presence of the poisonous mixture. Unfortunately, I had no opportunity of testing this matter myself and therefore am unable to decide in regard to the truthfulness of this statement from personal experience.

Much might be accomplished in the matter of preventing the appearance in the cultivated orchards of the migrating swarms by destroying either the eggs or the young locusts in their natural breeding grounds. In a previous chapter I have given my reasons for believing that the swarms of locusts that occasionally appear in portions of the San Joaquin and Sacramento Valleys hatch out in the pasture lands among the foothills along the western base of the Sierra Nevada Mountains, in land overgrown with tarweeds. The eggs in these breeding grounds might be destroyed either by burning over these grounds late in the autumn after all of the eggs are laid, or by plowing under the eggs to a depth of 6 or 8 inches at any time before they hatch out in the spring. The eggs of the migrating California locust have never been seen by me, but there is every reason for believing that they are deposited in the same manner as those of other species belonging to the same genus. These are deposited in a mass, the upper part of which is nearly on a level with the surface of the ground, while the lower part is within three-quarters of an inch of the surface. It is very probable, therefore, that where there is any considerable quantity of dry weeds and other litter scattered over the breeding ground, by setting fire to this litter the heat generated from it would be sufficient to destroy all of the eggs existing in the ground thus burned over.

Instead of thus destroying the eggs it might be advisable to wait until the young locusts have hatched out in the following spring, and then destroy these young ones before they have acquired wings and migrated from the breeding grounds. This could evidently be accomplished with the least trouble and expense by scattering the bran and arsenic mixture over the breeding grounds shortly after the young locusts first make their appearance. In case that these breeding grounds occur in pasture lands it might be advisable to fence them in, so as to prevent the stock from being poisoned by this mixture put out for the locusts. I am not aware that stock of any kind will feed upon the tarweeds, so that but little loss in pasturage would be experienced if the stock were to be prevented from ranging over patches of them. I have been credibly informed that this method of poisoning the young locusts in their natural breeding grounds has been practiced in Fresno County for several years past, and that since it was first adopted no serious outbreaks of locusts have occurred in that county.

The fact as above stated that the Devastating Locust breeds only or almost wholly in places overgrown with tarweeds would indicate that if these weeds were destroyed by being plowed under, and later by thoroughly cultivating the soil, so that those appearing afterward would be destroyed, the locusts would no longer choose such places for oviposition; and just in proportion as this practice was extended, in the same proportion would there be a less number of the locusts produced in the localities operated in. And if it were possible to wholly eradicate these patches of tarweeds, that would evidently settle the question of locust ravages in that section of country for all time to come. Not only should the tarweeds in the pasture lands among the foothills be destroyed, but also those growing along the roadsides and in waste places about cultivated fields, since the locusts which hatch out in such places aid in no small degree the devastating work of the migrating swarms. Too much stress can not be laid upon this subject of preventing, as far as possible, the breeding of the locusts, and of destroying the young ones before they acquire wings. It has been the unfortunate experience of many of our orchardists in the region of country subject to these locust invasions, that after once the locusts have acquired wings and come into the orchards in immense swarms, one following the other, little or no headway can be made against them; our greatest efforts, therefore, should be directed against these pests before this stage of their existence is reached, and while it is still within our power to successfully cope with them. In this respect, an ounce of prevention is worth many pounds of cure.

In the case of small trees these can be protected from the ravages of the locusts by being covered with sacks of cloth or of paper, allowing these to remain upon the trees until all of the locusts have passed away. For this purpose common barley or gunny bags, oat-meal sacks, and paper sacks of various kinds have been used. These were simply slipped over the young trees from above and the mouth of the sack tied about the trunk of the tree. In place of sacks some persons employed old newspapers, which they wrapped around the trees and fastened with strings. I saw several hundred young orange, prune, and various other kinds of deciduous trees which were inclosed in barley sacks, and I was informed that the sacks had been on the trees for over five weeks, still when several of them were removed the trees appeared to be as healthy and vigorous as any I ever saw. It was reported that a large number of trees had been killed by thus being covered with sacks, but I was unable to find a single case where this had occurred. The following paragraph on this subject is from the *California Fruit Grower*, of San Francisco:

> During the recent grasshopper invasion A. J. Lloyd, who has an orange orchard near town, covered his young trees with gunny sacks, to prevent damage, as reported by the Oroville Mercury. The effect has been most disastrous, for upon removing the sacks it was found that about 900 trees had been killed.

One orchardist who had used barley sacks successfully for the purpose of protecting his young orange and prune trees from the attacks of the locusts, informed me that some of his neighbors had used paper sacks with the result of killing the trees, but I was unable to ascertain how much truth there was in this assertion. I saw quite a large number of prune and olive trees that were wrapped in papers which I was informed had been on the trees for three or four weeks, but these trees had not been injured in the least by this treatment. A lady owning an orchard of young fruit trees near Pasadena found that the leaves of several of the trees had been eaten by a kind of May-beetle, *Serica fimbriata* Lec., which remained hidden from sight in the daytime and came forth only at night to feed upon the leaves. Having been applied to for advice I recommended that the trees be inclosed in barley sacks, and that they be allowed to remain upon the trees for a period of about three weeks, or until the May-beetles had passed away. Accordingly this was done, and during a recent visit to this orchard I found that the sacks had been duly removed and the trees were now growing vigorously, being to all appearances none the worse for their temporary imprisonment. This would at once disprove the assertion that trees are injured by being confined in sacks of this kind.

Of course, this method could only be employed for the protection of small trees; on large trees it would be altogether too expensive.

REPORT OF A TRIP TO KANSAS TO INVESTIGATE REPORTED DAMAGES FROM GRASSHOPPERS.*

By HERBERT OSBORN, *Special Agent.*

LETTER OF SUBMITTAL.

AMES, IOWA, *August 19, 1891.*

SIR: I beg to submit herewith my report of a trip, made in accordance with instructions received July 24, 1891, to investigate reported damages by grasshoppers in Kansas during the current year.

Very respectfully,

HERBERT OSBORN.

Prof. C. V. RILEY,
U. S. Entomologist.

In accordance with instructions received July 24, to visit and report on grasshopper injury in western Kansas, I started the following morning for Kansas and improved every opportunity on the way to learn of grasshopper injury. At Des Moines, where I waited a few hours for the Kansas City train, I went through a large number of Kansas papers, kindly placed at my service in the office of the *State Register* and *Iowa Homestead*, without, however, getting any information except assertions in some places that there were no hoppers in Kansas.

From a gentleman lately through Arizona I learned of the appearance of considerable numbers in that Territory and the expectation that these might be traveling eastward. At Kansas City I was equally unsuccessful, the only information received there being the statement of railroad men as to the occurrence of hoppers on the railroad in Colorado (the case investigated by Professors Snow and Popenoe), and of some in Arizona, along the line of the Atchison, Topeka and Santa Fé Railroad.

At Topeka I went first to the office of the State Board of Agriculture. The Secretary, Mr. Mohler, was absent, but the gentlemen present, Messrs. Longshore and Nyswander, kindly gave me a full statement as to the information the office contained.

They receive reports from over six hundred correspondents who are scattered over the entire State, the western portion being well repre-

* Reprinted from INSECT LIFE, vol. IV, p. 49.

sented. They assured me that not a single report had been received by them which mentioned injury from grasshoppers, and they were positive that no damage was being done.

At the newspaper offices I received similar replies, except that in the office of the *Kansas Democrat* I learned of a report that some damage had been done in Kearney County. As this report, however, was somewhat indefinite, I hesitated to make it the basis of a special trip to the extreme southwest part of the State, and, Lawrence being so near at hand, I concluded to go there to see if Professor Snow had any recent information.

Professor Snow was absent, but his assistant, Mr. V. L. Kellogg, kindly gave me all the information he could. He said that they had heard nothing from the region that had been examined by Professors Snow and Popenoe in Colorado, except that the winged insects were moving south, and he was sure that none of these had entered Kansas.

He also informed me that they had received information of injuries at Garden City, and showed me specimens of *Caloptenus differentialis* and *bivittatus* received from there.

This information tending to substantiate the report of damage in Kearney County, I decided to visit Garden City and took the first train for that place. On the way I kept careful outlook for any signs of damage, and improved the opportunity of occasional stops to collect specimens and inquire of residents as to the prevalence of grasshoppers. All answers agreed in denial of any unusual numbers of grasshoppers or of injury from them, and it was not till I reached Garden City that I learned of any damage. Here I was told that the alfalfa fields were being ruined, and it was only a short time after my arrival that I was in a field a mile from town where the conditions showed at once the state of affairs to be serious.

The alfalfa was badly stripped, the blossoms and seed entirely eaten up, and in many patches the stems were stripped bare of leaves, looking brown and dead.

The grasshoppers, mostly *differentialis*, with a considerable number of *bivittatus*, when rising in front of me as I walked through the field, formed a cloud 8 or 10 feet high and so dense as to hide objects beyond them. Here I noticed a number of grasshoppers dead from the attacks of parasitic Tachinids.

From this field I went to another, owned by the same man, which was also well filled with grasshoppers, but the injury here was less, especially around the buildings, where a large number of turkeys were doing excellent service in killing the hoppers and at the same time adding rapidly to their own weight.

In a field of sorghum directly adjoining there was also considerable injury, but *differentialis* seemed scarce, while a bright green species, *Acridium frontalis* Thos., was abundant and apparently the principal agent of destruction. This species was also noticed here and in other

places occurring in great abundance on the Wild Sunflower so common on these plains, and the question arose whether this was not its natural food plant and its attacks on sorghum incidental.

The day following I spent the forenoon with Dr. Sabin, who kindly furnished a horse and cart and accompanied me in examining a number of farms within 5 miles of Garden City, where alfalfa fields and orchards were injured. I met and talked with a number of farmers who had suffered from grasshopper depredations, and the information received from them with what I gained by personal observation satisfied me that losses could be avoided by proper measures.

I learned that the same injuries extended farther west along the river where alfalfa was grown, and I proceeded from Garden City to Lakin, observing on the way that all alfalfa fields showed presence of grasshoppers, but that in some cases the bloom was still free from serious injury or destroyed only in patches. At Lakin I learned that injury had been serious, especially on the place of Mr. Longstreth, some two miles from town. Some fields near the river and occupying low land were noticed in full bloom and showing little damage, but still grasshoppers could be found in abundance by closer inspection of the fields.

Mr. Longstreth's son, being in town, drove me out to his father's farm, and accompanied me on a tour through his extensive orchard of 10 acres, his oat field and alfalfa fields, in all of which the damage had been serious. Many of the trees in the orchard were entirely stripped of leaves, and in some cases the bark had been eaten from the limbs. The alfalfa presented the same appearance as observed in other fields. I found here a great many dead grasshoppers, whose empty shells attested the activity of Tachinæ.

I was told by Mr. Longstreth that skunks were amongst the most active enemies of the grasshoppers, and he believed played an important part in reducing them. He had even seen one up in an apple tree catching hoppers on the limbs.

I learned at Lakin that alfalfa was also grown in the next county west, at Syracuse, and that damage was also reported there, but on reaching the place found the injury slight as compared with the other places visited. In fact, aside from one farm on which some damage to alfalfa and orchard had occurred I could learn of no loss. *Caloptenus differentialis* I found in some numbers, and there is little doubt that unless some effort is made this fall and next spring to destroy eggs and young they will multiply as in other localities, and probably by next season prove as destructive as in them.

As this point carried me into the westernmost row of counties in the State, and there was no report of damage farther on, I determined to cross northward to the Missouri Pacific Road, in order to follow up some rumors regarding damage from grasshoppers at some points intervening, and which, from the descriptions given, seemed possibly to be due to *Dissosteira longipennis*. No point where serious loss occurred was found, however, and this species occurred but sparingly at points between

Syracuse and Tribune, and occurred at Horace only in small numbers, too few to cause any apprehension for the immediate future at least. Taking the Missouri Pacific, I passed through to Kansas City without finding any evidence of damage from grasshoppers, and as I could learn of no other localities in the State than in the three counties examined where such damage was reported, I returned to Ames, and will now proceed to a detailed account of the territory examined, the species observed, and the special measures needed to meet the outbreak in this section.

THE TERRITORY AFFECTED.

The damaged territory is quite easily defined and might very properly be said to coincide with the irrigated portion of the Arkansas Valley lying in Finney, Kearney, and Hamilton counties in southwest Kansas. The entire irrigated district, however, is not equally injured and there are some fields much less damaged than others. The whole area covered extends with occasional breaks a distance of about 50 miles along the river and forms a strip from 1 to 5 miles wide but limited entirely to areas where irrigation has been practiced, and within this limit is dependent upon the kind of crops raised.

The greater damage was observed at Garden City, though nearly as bad was seen at Lakin, and but little was found at Syracuse, corresponding as near as I could learn pretty closely with the length of time since alfalfa has been made a principal crop on the irrigated lands.

THE CROPS AFFECTED.

Alfalfa is the crop in which there is the most loss, but orchards are suffering badly, and were they extensive throughout the district would very probably present the heavier loss.

The alfalfa crop is a very profitable one and easily grown with irrigation, and has been very extensively planted, the fields devoted to it covering many thousands of acres.

The injury to this crop is of such a nature that I believe practical remedies may be adopted, and, as will be stated later, active measures should be adopted this fall and next spring.

THE AMOUNT OF INJURY.

The great loss this year has resulted from the destruction of the seed crop. In many fields this has been a total failure, and the loss may be considered as covering thousands of acres and involving many thousands of dollars. One man who had something over 100 acres in alfalfa considered that his loss amounted to about $2,000. While he expected to cut and use the crop for hay, the damage had been such that the hay would be little better than after the seed crop had been secured, and he reckoned the full loss of the seed crop for the season. In some cases

farmers were cutting for hay when they had intended to allow the crop to go to seed, and in this way were reducing the amount of their loss by the value of the crop of hay cut early over what the hay would be worth after maturing seed, the latter, of course, being much less valuable than the hay cut before seed matures. In many cases the farmers had been depending largely upon the crop of seed to help them out of debt, and the loss from the grasshopper injury falls heavily upon them.

THE SPECIES DOING THE DAMAGE.

The Differential Locust is, I think, chargeable with fully nine-tenths of the destruction, both in alfalfa and orchards, and the reasons for its increase in this section seem to me quite evident. The irrigated fields of alfalfa furnish it with favorite food in abundance throughout the year and have given it an opportunity to multiply rapidly without exhausting its food supply.

The ditches which traverse the fields and possibly parts of the fields themselves furnish a most excellent location for the deposition of eggs, the ground being compact and for the most part undisturbed throughout the year. That the eggs are deposited in or alongside the ditches is indicated by several facts, though at the time of my visit the locusts, while pairing, were none of them ovipositing. In the first place, the greatest damage has occurred in strips on either side of the ditches, and only in the worst fields extends over the entire field; second, at the time of my visit the pairing individuals were quite evidently collecting more particularly in these locations; third, the testimony of those who seemed to have observed most closely agreed in placing the greatest number of young hoppers in spring along the borders of the ditches, a point which is clearly supported by the injured strips so plainly to be seen. No one whom I questioned had seen the locusts in the act of ovipositing.

The ditches contain no water during a large part of the year, and in fall the compact bottom, which doubtless affords more moisture than the fields in general, would seem an excellent place for the deposition of eggs, as well as the banks on either side. Judging by the habits of these and allied species in other locations it would be hard to conceive a more favorable place for the deposition of eggs, and it seems to me very probable that this, as well as the suitability and abundance of the food, may be considered an important factor in the rapid increase of the species in the last three or four years, an increase that has taken place directly with the cultivation of alfalfa by irrigation.

It would seem also that this habit renders the insect especially open to attack, and I see no reason why concentrated effort may not entirely prevent a repetition of the damage another year.

MEASURES RECOMMENDED.

The situation, it seems to me, is one deserving serious attention, but

one which offers every hope for successful work, if the residents of the affected localities can but be induced to make a little effort at the proper time.

The means which appear to me from inspection of the ground to promise most successful results would be as follows:

(1) To thoroughly break up the surface of the ground in and along the ditches before winter by harrowing thoroughly, cultivating or shallow plowing, thus exposing the eggs to winter weather and natural enemies.

(2) Wherever practicable, to flood the ground for a day or two at the time young locusts are hatching. I was told that the young hoppers were entirely unaffected by water, as they would crawl up the alfalfa stems and escape, and it is probable that sufficient flooding to accomplish much good in this region is out of the question. My only hope in this line would be in watching carefully for the time of hatching, and using the water before the hoppers had obtained any growth, and if abundant along the ditches, putting a little kerosene on the water.

(3) A use of the hopperdozer as early in the season as possible, when I believe the treatment of a strip 8 or 10 feet wide on each side of the ditches would destroy so large a part of their numbers as to prevent any serious damage. As I learned from a number of parties the hoppers are scarcely half grown when the first crop is cut, it would seem that immediately after cutting the first crop would be the best time to use the hopperdozer. The hoppers would be large enough to jump readily and the dozers could be run very easily. It would be difficult to use them at any other time than directly after a crop was cut, as the dense growth of alfalfa would obstruct their movement.

My strongest recommendation would be the urging of effort in breaking up egg masses before winter, and then in case locusts still appear in any number in spring to resort to the dozers at first opportunity. I believe active use of these measures will be effectual, with a cost but trifling compared with the value of the crop to be saved.

The information as to the species and the measures needed are covered very fully in your Bulletin on Destructive Locusts,* and with some specific instruction regarding the treatment of ditches in this special locality would, I think, give the people of the district affected all the information necessary to protect themselves, and it would seem advisable to send a number of copies of that bulletin to the postmasters at Garden City, Lakin, and Syracuse, to distribute to farmers, who would make use of them, as well as to those whose names I will furnish for this purpose.

OTHER SPECIES OBSERVED.

The species next to *differentialis* that I should call most abundant in the injured fields was *bivittatus;* but taken alone its damage would

* Bull. 25, Div. of Entomology, U. S. Dept. Agriculture.

have been insignificant. Its habits are so nearly like those of *differentialis* that I see no occasion to give it further mention, and I have little doubt that any measures adopted against *differentialis* will prove as effective against this species.

Dissosteira longipennis was taken in some numbers at all points visited in Finney, Kearney, Hamilton, and Greeley counties, and as this species has caused so much injury in eastern Colorado this season, I took rather special pains to note its abundance and inquire as to any destruction resulting from it. At no point did it occur in destructive numbers, and I should not look for any injury from it in these localities in the near future at least.

PARASITES AND DISEASES.

The many parasitized grasshoppers noted indicated a multiplication of such forms, and these will undoubtedly accomplish much in reducing the numbers that can deposit eggs this fall, but I should deem it unwise to depend on them and to omit the active measures already urged.

The most general parasites were apparently the Tachina flies, as the great majority of dead hoppers were found to be completely devoured within.

Some of the dead grasshoppers had the appearance of having been affected with Entomoyhthora, and I gathered a number in order to make an effort to cultivate the disease, but as yet have nothing to report in this line. The dead hoppers will be kept with living ones, and if the latter take the disease we may hope to still further multiply the disease by inoculating still others, and then an effort can be made to distribute the disease in the fields. Its spread, however, is evidently slow, and I do not think other measures should be neglected this season for a plan which is still uncertain.

Among the natural enemies observed, toads were perhaps the most common, some of the fields containing great numbers of them, especially of half-grown individuals, and these would seem capable of greatly reducing the number of hoppers. A dead one, which saved me the necessity of making a dissection to get positive proof, showed in the partly decomposed stomach the legs and other parts of grasshoppers, proving that, as would be inferred from presence of toads in the fields, their mission was to feed upon the grasshoppers.

The attacks of skunks upon grasshoppers, as stated by Mr. Longstreth, have already been mentioned.

As the tendency is for natural enemies to multiply with the increase of any species of insect, we may look for increased assistance from this source by another year, and in connection with the measures already urged, these ought by another year to keep the insect entirely within the limits of destructiveness.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 28.

THE MORE DESTRUCTIVE LOCUSTS OF AMERICA NORTH OF MEXICO.

BY

LAWRENCE BRUNER.

(PUBLISHED BY THE AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1893.

CONTENTS.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., October 15, 1892.

SIR: I have the honor to submit for publication Bulletin No. 28 of this Division. It comprises an account of the destructive locusts of the United States, and of those species which are liable to become destructive, and may be looked upon as supplementary to Bulletins 25 and 27 of this Division. It has been prepared by Mr. Lawrence Bruner, the agent of the Division at Lincoln, Nebr., who has been associated with me in the study of the family to which these insects belong, and since the completion of the work of the Entomological Commission has made a special study of the true locusts of North America, materially aiding in the investigations of the injuries caused by them of late years.

Respectfully yours,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

LINCOLN, NEBR., *October 20, 1892.*

SIR: Since there has been an apparent increase in the number of certain of the destructive locusts in many parts of the country during the past two or three years, it has been deemed advisable to prepare a brief account of all of the species that have been connected with these depredations. The following pages on the Destructive Locusts of America North of Mexico are therefore submitted for approval and for publication, if thought worthy. As will be seen, this paper covers all of the forms that have been the cause of injury in the past, as well as those that are liable to do injury in the future.

The manuscript which forms this paper was originally prepared as a part of another report,* but at your suggestion has been somewhat rearranged so as to make a separate bulletin, if thought desirable. The excuse for offering this paper at the present time is that, although all of the insects herein mentioned have been previously described, the literature in which the descriptions originally appeared is so scattered and difficult of access that the general reader would have trouble in refer ring to it. Besides, many of these works are now out of print. Then, too, a paper treating of the entire group of these destructive insects of the region included is in demand by both the working entomologists and the general reader. The short sketches relative to the food habits and distribution of each of the species treated have been compiled from previous writings and field notes gathered by the various agents of the United States Entomological Commission and the Division of Entomology, and are supposed to be approximately correct, at least as nearly so as could be made at present, while the life histories are chiefly from your own notes and observations.

Through your kindness and interest in the undertaking a number of the forms are herewith figured for the first time. Other courtesies are also gratefully acknowledged.

LAWRENCE BRUNER,
Special Field Agent.

Prof. C. V. RILEY,
U. S. Entomologist,
Washington, D. C.

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* Reports on the Damage by Destructive Locusts during the season of 1891. (Bull. No. 27, of U. S. Department of Agriculture, Division of Entomology, pp. 9–33.)

THE MORE DESTRUCTIVE LOCUSTS OF AMERICA NORTH OF MEXICO.

If one were to describe or even to mention all of the locusts that are injurious to vegetation in this country every species would have to be included in such a list. Taken as a group there are no exceptions to the general rule in this particular case. Every member of the family is a vegetable feeder, and hence is to be considered as harmful from the agricultural standpoint. As certain restrictions are absolutely necessary in the preparation of this report, only a few from among the many of these insects will be treated, and these briefly. Accordingly herewith is appended a list of the different locusts or grasshoppers that have been known to occur in destructive numbers within the limits of North America north of the Mexican boundary during the past twenty or thirty years, together with such other species as are liable to become destructive in the future.

Every warm or temperate country of any extent of which a considerable portion is arid or semidesert, or where the climate is liable to variation, has its locust swarms. Of all insect pests these swarms of locusts are generally most dreaded, because of their manner of attack and the rapidity with which they can and do lay waste a country or district. Other insect enemies may do an equal amount of injury during the year, but as it is not done "right before our very eyes," we do not think so much of it.

These destructive locusts may be divided into two classes with respect to their habits, viz, they are either migratory or they are nonmigratory. When the former, they move about over the country from one region to another and drop upon us without much warning. When the latter, they simply multiply, do their injury, and remain where they are. Likewise, these destructive locusts may belong to either the one or the other of two subfamilies, *i. e.*, the Œdipodinæ and the Acridiinæ. Here in North America most of the destructive species belong to the subfamily Acridiinæ, while in the Orient the reverse is probably the rule.

The members of the subfamily Œdipodinæ are at once recognizable by their colored hind wings, the unarmed sternum of the prothorax, and in having the cushions between the claws of the feet very small. The Acridiinæ, on the other hand, usually have the hind wings transparent, the prosternum always spined, and the feet provided with a rather large cushion between the claws. The members of the group Œdipodinæ are usually further recognizable, from the fact that they

are, as a rule, provided with a more or less prominent median carina or ridge upon the pronotum, while in the Acridiinæ this character is usually very obscure.

THE AMERICAN LOCUST.

(*Schistocerca americana* Drury.)

The accompanying illustration (Fig. 1) of a female specimen of this large, handsome insect will at once indicate to the reader which one of all our locusts should bear the above name. The following description will facilitate the identification of the species:

Female (*large size*).—Vertex between the eyes hexagonal, with a central depression; frontal costa solid and somewhat prominent above the ocellus, sides nearly parallel. Eyes elongate oval, rounded behind; straight in front. Pronotum expanding at the posterior lobe; median carina but slightly prominent; humeral angles subdistinct on the posterior lobe, obtusely rounded; anterior and middle lobes marked with minute shallow cells, each having a very minute tubercle in the center; posterior

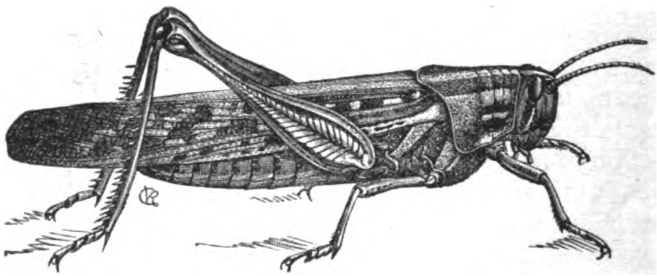


FIG. 1.—*Schistocerca americana*—natural size (after Riley).

lobe densely punctured; posterior margin about right-angled; apex rounded. Tegmina and wings passing the abdomen about one-third of their length. Posterior femora reaching the apex of the abdomen. Prosternal spine large, curved backward and hairy.

Reddish-brown, with a slight vermilion tint. A yellow stripe extends from the vertex along the middle of the head and pronotum, and also upon the suture of the closed tegmina as far as the tip of the abdomen. A dark brown line down the cheeks below the eyes. On the sides of the pronotum is a yellow stripe extending from the submarginal to the last cross-incision, directed a little obliquely downward; below this is a brown stripe; then a narrow yellow stripe directed obliquely upward; lower margin yellow. The tegmina are opaque and reddish at the base, the rest, semi-transparent; a narrow white stripe on the lower margin, next the base; the disk and apical half marked with large cellular, fuscous spots. Wings transparent; the nerves at the base and inner portion yellowish-white, on the outer portions black. Legs, bright vermilion red. Posterior femora have a row of black dots along the upper and lower margins of the disk and one through the middle; spines of posterior tibiæ yellow, tipped with black. Each segment of the abdomen has a ring of dusky dots on its posterior margin.

Male.—The male differs from the female in being much smaller. It has the sub-anal plate prolonged and deeply notched at the apex; the cerci are very broad, straight, and truncate at the apex.

Length of body—male, 1.7 inches; female, 2.1 inches; tegmina in both sexes same as body.

This handsome locust is most commonly met with in the region lying south of the fortieth degree of north latitude, but is by no means absent from all the territory north of that parallel. It occurs north of this line in Nebraska, South Dakota, Iowa, Illinois, Indiana, Michigan, Ohio, Pennsylvania, New Jersey, and perhaps even New York. It does not, however, become destructive much beyond the Gulf States. It is the chief destructive species of Yucatan, Central America, and southern Mexico. In fact, it is very closely allied to the large Wandering Locust of the Orient (*Schistocerca peregrina*), and by some authors is claimed to be only a variety of that species. Be this as it may, every warm country of the globe, island, or continent lying within the tropics or within the adjoining 15 degrees of the temperate zones has one or more of these large locusts that show a wonderfully close relationship to our *Schistocerca americana*. Most of them are also frequently destructive, while a number of them are exceedingly migratory in their habits.

THE LARGE GREEN BUSH-LOCUST.

(*Acridium shoshone* Thos.)

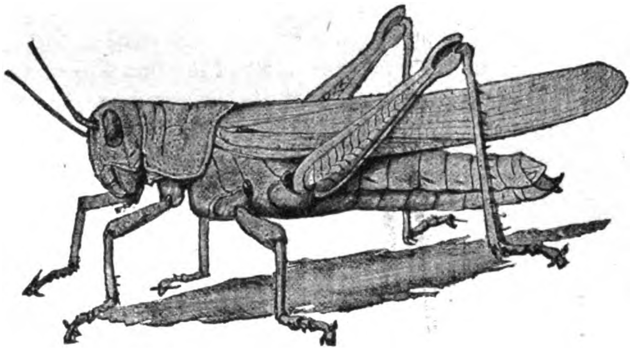


FIG. 2.—*Acridium shoshone*—natural size (original).

This insect is described by Prof. Thomas as follows in his report on the Orthoptera collected by the Wheeler Expedition in the Southwest:

Female.—Vertex nearly horizontal; sides angularly expanding in front of the eyes; flat frontal costa prominent, sides parallel, sulcate from the ocellus downward, above the ocellus somewhat gibbous and punctured; lateral carinæ very prominent, parallel. Pronotum slightly expanding posteriorly, coarsely and reticulately punctured; midian carina distinct, severed by the three transverse impressions. Tegmina and wings passing the abdomen. Cerci very short, broad at the base, narrowed and rounded at the apex. Posterior femora much enlarged at the base; posterior tibiæ considerably enlarged at the apex. Prosternal spine robust, cylindrical, and nearly straight. Pectus punctured. Abdomen of the male somewhat elongated; cerci very broad and flat, very slightly and obtusely notched at the apex, which is bent upward over the last segment; subanal plate elongate, turned upward, with a distinct square notch at the apex.

Dark olive-green. Ocelli bright transparent umber; eyes brown; cheeks yellowish, with a dark green stripe extending downward from the eyes. The pronotum

has some pale spots on the sides, and sometimes the posterior lobe is tinged with brown. Tegmina uniform green, somewhat transparent at the apex, and in some specimens faintly tinged with brown. Wings hyaline; nerves and nervules dark brown. Posterior femora greenish above and below; pinnæ of the disk alternately white and green, the white occupying the flat interspaces; inner face greenish yellow. Posterior tibiæ bright vermilion, the under surface being striped with yellow; spines yellow at the base, tipped with black. Venter and pectus dark green, sometimes varied with dark brown.

Length of body—male, 1.6 to 1.75 inches; female, 2 to 2.25 inches; tegmina and wings about one-fifth less.

This magnificent locust, which is fully as large as *americana*, was first described from Nevada and Arizona, but has since been taken in Utah, California, New Mexico, Texas, and across the border in the States of Chihuahua and Durango in Mexico. Several years ago the writer found it quite abundant in the vicinity of El Paso, Tex.; and Prof. C. H. T. Townsend, of the New Mexico Agricultural College, reports it as destructive to the Mesquite bushes and probably also to grape-vines in portions of New Mexico. Being strictly an arboreal insect, *shoshone* is liable to become more or less of a tree pest when numerous. In Utah this insect was taken by me upon various low trees growing on the lower mountain slopes back of Ogden, Salt Lake City, and near Garfield Beach. It was also occasionally taken in the valleys on Willows, and even upon some of the rank-growing herbs; but I have never seen or taken a specimen of it upon the ground.

It has been treated here because of its occurrence in destructive numbers in 1891 in portions of New Mexico, and because its life as a tree-dweller is sure to favor its greater multiplication with the advance of civilization.

THE SMALL GREEN LOCUST.

(*Acridium frontalis* Thos.)

Another one of our locusts belonging to the genus Acridium that has quite recently shown a tendency towards becoming a pest is the one bearing the above name. It was found by Prof. H. Osborn in southwestern Kansas the past summer, where it was doing considerable injury to the sorghum crop of that region. It was also observed by me in central Texas in the spring of 1887, where it occurred in more than common numbers.

FIG. 3.—*Acridium frontalis*—natural size (original).

The insect appears to be growing more and more fond of cultivated grounds, as is shown by its habit of congregating along wagon roads and the edges of fields among the ranker growths of the vegetation that is common to such places. In its haunts and food habits *Acridium*

frontalis is inclined to be a little particular, just as are a number of other species of our North American insects belonging to this family; but its tastes can not be considered refined when it is known that chief on its bill of fare comes the wild Sunflowers so common throughout that portion of the West to which the insect is characteristic. It also seems to relish the Sorghum plant, which latter is entirely ignored by the Rocky Mountain Locust.

This locust can be recognized by the following description:

Vertex subconical. Small size. Tegmina and wings not passing the abdomen. General color, green.

Closely allied to *A. unilineatum* Walk.; caloptenoid in general appearance. Vertex regularly hexagonal, standing out in the form of a very short, truncated cone, the tip depressed in the center; face slightly oblique, straight, quadricarinate; carinæ nearly parallel, the middle pair approaching each other immediately below the ocellus. Eyes elongate, oblique, straight in front. Pronotum scarcely enlarged behind; anterior lobes reticulately, and posterior lobe longitudinally, rugulose; median carina very distinct. Tegmina and wings narrow, rather shorter than the abdomen. Valves of the ovipositor prominent, lower pair much slenderer than the upper pair, and much exserted. Male cerci slender, tapering, and turned up; subanal plate (last ventral segment) narrow, tapering; subtruncate at the apex, entire. Prosternal spine subquadrate, pointed, and straight. Antennæ passing the pronotum slightly. Posterior femora passing the abdomen.

Nearly uniform grass-green. Face and pronotum sprinkled with dusky dots. The elevated lines of the pronotum pale yellow, more or less tinged with red. The upper edges of the posterior femora also more or less tinged with red. Antennæ, orange color. Tegmina somewhat lighter green than body; transparent. Wings, pellucid.

Length of body—female, 1.06 inches; male, 0.82 inch. Length of tegmina—female, 0.63 inch; male, 0.5 inch.

Although *frontalis* is found as far north as Bismarck, N. Dak., it is essentially a southern insect. Especially is this true with respect to its presence in destructive numbers. It is a common species in Nebraska in certain localities, is found in eastern Wyoming rarely, and in eastern Colorado and northeastern New Mexico more frequently, while in Kansas and southward it becomes quite numerous, especially upon rolling, more or less sandy soil. To the eastward it reaches into western Iowa and central Missouri.

We have several other species of these large Acridians within the limits of the United States, all of which occasionally show a tendency toward uncommon multiplication.

These are *Acridium appendiculatum*, *A. rubiginosum*, *A. alutaceum*, *A. obscurum*, *A. unilineatum*, and *A. albolineatum*. The *Schistocerca vaga* also should be included among the latter species. All of these insects are arboreal in their habits, and live the greater portion of their lives above ground in wooded districts, and on this account are rather hard to deal with.

THE LONG-WINGED FOREST LOCUST.

(*Dendrotettix longipennis* Riley.)

This particular species is the one mentioned in Bulletin 13 of the Division of Entomology, U. S. Department of Agriculture, as the Post-oak Locust. I quote Prof. Riley's specific description of the insect:

Dendrotettix longipennis Riley.—General color testaceous with slight olivaceous hue, varied with faint yellow and piceous bands and lines; face dull olivaceous brown; occiput, especially back of the eyes, darker. Pronotum olivaceous with more or less yellow; median carina and the transverse impressed lines on the lateral bands piceous, generally darkest and most continuous in the ♂. Tegmina dull olivaceous brown, the veins being testaceous and giving the basal half a decidedly lighter coloring. Wings rather dark, becoming somewhat pellucid near their base, the veins dusky, especially on their apical half. Posterior femora with their outer face dull olivaceous and marked with brown and black along their upper edges and crossing to the inner surface, which, with the lower sulcus, is bright sanguineous, this coloring showing through the somewhat transparent walls even on the outside; the apex black, preceded by a rather wide and very distinct lemon-yellow annulus; hind tibiæ with a wide post-basal annulus of the same bright color; anterior and middle legs, also the tarsi of the hind legs gamboge-yellow, with the spines and claws black; antennæ fuscous, olivaceous towards tip. Venter gamboge-yellow.

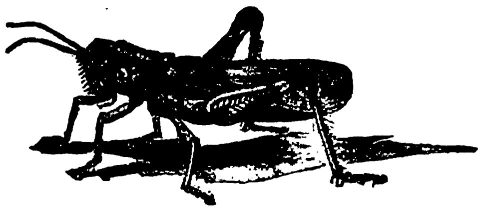


FIG. 4.—*Dendrotettix longipennis*—natural size (original).

Average length ♂ 25mm, ♀ 30mm.

The short-winged forms agree in all other respects except that, as is the case with other genera, the tegmina do not ordinarily extend much beyond the second abdominal joint, and may be either perfectly rounded or slightly twisted at the apex. In some cases, however, they extend to one-half the length of the abdomen.

Described from 2 ♂♂ and 3 ♀♀ of the long-winged form, and 4 ♂♂ and 7 ♀♀ of the short-winged form. Received from E. H. Hill, Manor, Travis County, Tex., July 13, 1887, as injuring post oaks, and collected by Mr. Bruner.

The Long-winged Forest Locust or "Post-oak Locust" of Texas, as the name would imply, is also an arboreal insect. It is shown in the accompanying illustration (Fig. 4).

This locust was first noticed by the inhabitants of Washington County, Tex., about the year 1885, when it attracted their attention by defoliating the post-oak trees over a considerable extent of territory lying to the eastward of the town of Brenham. In the spring of the following year I had the privilege of studying the species to some extent while visiting the region to examine into a local outbreak of another locust that threatened the cotton and corn crops. The following in reference to its habits and mode of life I copy from a report made at the time:*

"The egg pods are deposited in the ground about the bases of trees or indifferently scattered about the surface among the decaying leaves,

* Bull. No. 13, U. S. Dept. of Agriculture, Division of Entomology.

etc., like those of all ground-laying species. The young commence hatching about the middle of March and continue to appear until into April. After molting the first time and becoming a little hardened they immediately climb up the trunks of the trees and bushes of all kinds and commence feeding upon the new and tender foliage. They molt at least five or six times, if we may take the variation in size and the difference in the development of the rudiments of wings as criteria. The imago or mature stage is reached by the last of May or during the first part of June.

"The species is very active and shy in all its stages of growth after leaving the egg. The larva and pupa run up the trunks and along the limbs of trees with considerable speed, and in this respect differ considerably from all other species of locusts with which I am acquainted. I am informed that the mature insects are also equally wild and 'fly like birds.' They feed both by day and night; and I am told by those who have passed through the woods after night when all else was quiet, that the noise produced by the grinding of their jaws was not unlike the greedy feeding of swine.

"Aside from its arboreal nature there is but a single instance mentioned of its preference for growing crops. This was a small field of either cotton or corn, or perhaps both. If the nature of the crop was told me at the time, I have forgotten. At any rate the crop of one or the other of these two staples grew in a small clearing in the very midst of the most thickly visited area. The mature insects alone were the offenders in this instance. During the daytime they would leave the trees in swarms and alight upon the growing crop and feed until evening, when they would return to the trees. If, during the day, they were disturbed, they immediately took wing and left for the tops of the surrounding trees, to return shortly afterwards."

Mature specimens of this locust have since been obtained, which show the insect to be congeneric with *Dendrotettix guercus* Riley MS., a species found upon the oaks of Missouri, southeastern Nebraska, and southern Iowa and Illinois. *Longipennis* occurs in two forms, *i. e.*, with either well-developed wings or with those appendages in a rudimentary condition.

THE DIFFERENTIAL LOCUST.

(*Melanoplus differentialis* Thos.)

Very conspicuous among the "native species" of locusts in the Mississippi Valley and southwestward is the one which entomologists call *Melanoplus differentialis*. This insect is fully as large as the common two-striped species that is familiar to everybody who has noticed any insects of this class, but differs from it in being yellowish throughout and lacking the two stripes along the sides of the back and wings. The Differential Locust is also less robust in form than the one with which

it is here compared. The accompanying figure (Fig. 5), that of a female specimen, is not quite typical of the species, but will greatly aid in its recognition. The following description of this locust is that given by Prof. Cyrus Thomas, who named it:

Large size, robust; tegmina passing the abdomen, unspotted; olive brown above, yellow beneath.

Vertex elongate, depressed, broadly sulcate, closed in front; frontal costa broad, flat, or slightly sulcate; sides parallel; lateral carinæ distinct, slightly divergent. Antennæ of males half as long as the body. Pronotum quadrate; sides perpendicular, parallel; lateral carinæ or humeral angles obtusely rounded; median carina distinct, except on post-median lobe of the female; third transverse incision very distinct and deeply indented, others distinct. Posterior femora much enlarged near the base, the disk convex, about as long as the abdomen; posterior tibiæ enlarged toward the apex, hairy. Prosternal spine cylindrical, bent slightly backward. Subanal plate of the male triangular; apex blunt, entire; cerci with basal half broad, an obtuse tooth about the middle of the posterior margin, above this bent and tapering.

Color (*male*).—Head and anterior lobes of the pronotum reddish or olive brown; sides paler, with from one to three oblique, black lines; transverse incisions dark on the sides. Tegmina unspotted, olive brown; reddish at the base, semi-transparent. Wings pellucid; nerves of the apical and front portions dark, rest yellowish. Posterior femora yellow; three black spots on the upper edge; interspaces of the disk black, ribs pale yellow; tibiæ yellow, spines black. Abdomen yellow, with small, black spots and stripes. Venter and pectus yellow. The female differs from the male in having the head and thorax olive; the legs and venter a brighter yellow than her mate.

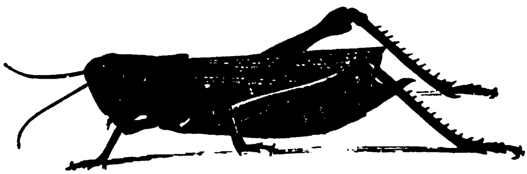


FIG. 5.—*Melanoplus differentialis*—natural size (after Riley).

Length of body—male, 1.2 inches; female, 1.5 to 1.7 inches; of tegmina—male, 1 inch; female, 1.25 inches.

This insect has very frequently multiplied in such numbers in limited areas over its range as to do considerable injury to cultivated crops growing upon low, moist ground; and has even been known very frequently to spread over higher and dryer lands adjoining these, its customary haunts. It is one of the few species of locusts that has thus far shown a tendency toward civilization. This it has done readily, since its habits are in unison with the cultivation of the soil. It is only since the settlement of the country where it originally occurred that it has multiplied so as to become sufficiently numerous to become a serious pest. *Differentialis* frequents plowed fields, and is a lover of rank-growing, juicy food, just such as is offered in Corn, Clover, Alfalfa, etc., as well as various garden products.

The eggs of *differentialis* are laid in cultivated grounds that are more or less compact, preferably old roads, deserted fields, the edges of weed patches, and well-grazed pastures adjoining weedy ravines. Egg-laying begins about the middle of August and continues into October, varying, of course, according to latitude and climatic conditions. Usually, but not always, only a single cluster of eggs is deposited by each

female. Frequently there are two, and in extreme cases perhaps even three, of these clusters deposited by a single female.

The range of this insect is not so extended as that of the Two-striped Locust, but nevertheless it is quite general west of the Allegheny Mountains and south of the forty-third degree of north latitude. It is common in Illinois, Indiana, Iowa, Kansas, Nebraska, Missouri, and is met with more or less frequently in southeastern Colorado, Indian Territory, New Mexico, Texas, Arizona, and California. In Kansas and Nebraska we often find black or nearly black specimens, while in California many of the insects of this species have the hind tibiæ bright coral red. Aside from these color variations the species is very true to its typical characters.

THE ROBUST LOCUST.

(*Melanoplus robustus* Scudd.)

Next to *Melanoplus differentialis* and very similar to it in general appearance and size is the large yellowish-brown and gray locust that is known by the name of *Melanoplus robustus*. This insect appears to be of rather local distribution since it occurs only in Texas, so far as I am at present aware. It was this insect that was chiefly concerned in the injuries wrought in central Texas during the years 1885 and 1886, and upon which I reported in Bulletin No. 13 of the Division of Entomology.

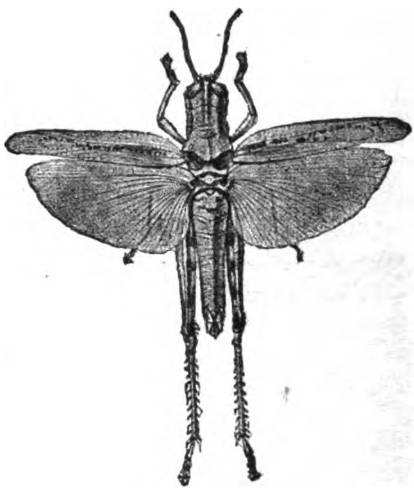


FIG. 6.—*Melanoplus robustus*—natural size (original).

The habits of this locust are given in that paper, and are briefly as follows:

"While the Rocky Mountain or Migratory Locust prefers rather solid soil upon somewhat elevated open fields and closely grazed pastures for depositing its eggs, all of these species now infesting central Texas appear to find more suitable conditions among rank herbage for the deposition of their eggs and subsequent development of the young larvæ. The large species especially finds the protected roots of grasses and corn best adapted to the sheltering of its eggs, and almost invariably selects the varieties which grow in clumps for this purpose. In digging I have found as many as 8 or 10 egg-pods inserted among the root-stalks of a single clump of grass. Possibly the sheltered nature of these eggs protects them from the numerous parasites which attack those of the Migratory Locust and other species which deposit in open or unprotected ground. It is

asserted by different persons in this region that the present species lays an average of 150 eggs to the pod, which, judging from the fragments of egg-shells found by digging, is nearly correct; at any rate the estimate is not too high. Egg-depositing with this species commences rather later than with some of the other representatives of the genus, but just at what date I did not learn. There is but a single pod formed by each insect, the entire complement of eggs being deposited at once.

"The larvæ commence hatching during the latter part of March and continue to appear up to the middle of April, according to the forwardness or backwardness of the season. Wet, warm weather favors the hatching, while dry weather rather retards the process. The young molt five times, at intervals of from twelve to twenty days, according to the condition of the weather. Dry weather with hot days retards, while damp or wet weather favors, this process among insects by keeping the exuviæ pliable during molting, as well as in furnishing the necessary moisture required in growth. The winged or mature insects appear about the middle of July or a little earlier and begin to copulate soon afterward, thus completing the cycle.

FIG. 7.—*Melanoplus robustus*—natural size (original).

"Their mode of attack does not differ greatly from that of *M. spretus*, save in that the latter begin upon the crops immediately after hatching, while this species does not. They wait until they are from three to four weeks old before venturing far from the places of hatching. Like that species they have the habit of huddling together upon plants and among grasses and débris during cool nights and cloudy days. This appears to be a trait common to all insects when present in large numbers, and must be the result of some special instinct. When about half grown the larvæ become pretty well scattered over the fields and do not hop back to the weed patches on the outskirts in the evening, as they do while younger and when beginning their attacks upon the crops. The molting is the same as with other locusts, and need not be described here. The grown hoppers do not migrate by flight, but do sometimes move in concert in certain directions by jumping. This can hardly be termed migration, since the change of location is merely performed for the purpose of obtaining food, while the act of migrating is toward obtaining more decided results. When feeding they can be driven like other locusts, and this trait in their nature has been taken advantage of at different times and by many of the planters as a means of partial protection to crops."

The description of this locust, as given by Mr. Scudder, is as follows:

Brownish fuscous with more or less of a cinereous tint. Front of head livid, very heavily mottled with dark brown; mouth parts pale. the tip of last palpal joint black, antennæ pale at base, beyond dull reddish more or less tinged with yellow, toward the tip infuscated. A slender, blackish stripe passes from behind the eyes to the hind lobe of pronotum, sometimes interrupted, sometimes accompanied by an infuscation beneath, broadening the band; upper surface more or less flecked with dark brown, sometimes collected into a V-shaped catch opening forward, the apex at the middle of the posterior lobe; hind border dotted with blackish; posterior lobe profusely, rest of upper surface sparsely, all shallowly, punctate; sides of metathorax with a pale oblique stripe narrowing upward to a point; tegmina blackish or brownish fuscous, flecked rather distantly with brownish spots, relieved by similar pale ones along the middle; legs of the color of the under surface, the fore and middle femora a little deeper or duskier; hind femora broadly bifasciate with blackish, the apex black at the sides; hind tibiæ and tarsi yellow, occasionally tinged with red, paler next the base, with a black annulus; spines black. Vertex broader (♂) or much broader (♀) than the first antennal joint, the fastigium with a scarcely perceptible depression (♀) or slightly sulcate (♂), broadening in front; frontal ridge broad, nearly equal, a little sulcate below the ocellus. Median carina of pronotum slight, distinct only on the posterior and anterior lobe, cut by all the transverse furrows; lateral carinæ rather distinct, rounded. Last abdominal segment of the male a little produced, rounded; cerci very large and stout, compressed, broadening apically, well rounded, very similar to those of *M. ponderosus*, but not so broad at the tip.

Length of body—male, 29.5^{mm}; female, 34.5^{mm}; of tegmina—male, 21^{mm}; female, 24^{mm}; of antennæ—male, 13.5^{mm}; female, 15^{mm}; of hind femora—male, 17.6 ^{mm}; female, 21^{mm}.

Melanoplus robustus is also quite closely related to the insect described by Prof. Cyrus Thomas as *Pezotettix viola*, which occurs in Illinois, Indiana, and Missouri. It is also related to *Melanoplus ponderosus* Scudd., of central Texas.

THE TWO-STRIPED LOCUST.

(*Melanoplus bivittatus* Say.)

Perhaps the most familiar locust to the greatest number of people in the United States is the one shown in Fig. 8, unless it should be the ordinary Carolina Locust, *Dissosteira carolina*. Although the illustration is a pretty fair representation of this insect, the following description is inserted for the benefit of those who wish to see it:

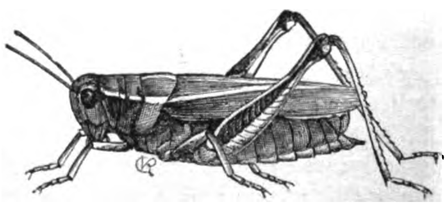


FIG. 8.—*Melanoplus bivittatus*—natural size (after Riley).

In this very common species the vertex of the female is convex or but slightly depressed, and the frontal costa not sulcate; in the male the frontal costa is more or less distinctly sulcate. Tegmina and wings but little longer than the abdomen. The last ventral segment of the male has the apical margin entire and circular. Pronotum with the sides straight, very slightly expanding posteriorly; posterior cross-incision distinct; posterior femora equal to or passing the abdomen.

Dull green or dull brown in color, with a distinct yellowish or pale stripe along each side extending from the upper angle of the eye, along the lateral angle of the body to the extremity of the tegmina. Mouth pale, face varies from pale yellowish to dark olive brown; as also do the tegmina; the latter sometimes have a few quite small dusky spots on the disk, but generally they are unspotted. Wings transparent, tinged with greenish or greenish yellow; nerves greenish brown or blackish. Hind femora generally with a dark stripe along the upper edge of the disk; yellow below; upper margin with two pale spots; posterior tibiæ variable, ranging from yellow to dark leaden brown.

Length of body—male 1 inch to 1.4 inches; female, about 1.7 inches, but frequently larger or smaller.

This locust occurs in nearly every locality over the entire country from the Saskatchewan River in the north to the Gulf of Mexico at the south, and from ocean to ocean. It is found in the low valleys near the seashore and upon the mountain slopes of the Rocky range and the interior plateaus to an elevation of nearly 10,000 feet above tide water. In fact, this particular species appears to be able to withstand more climatic variations than any other of our North American species, without showing marked variations in color and form. In size it varies more than do some of the allies. No wonder, then, that it occasionally becomes sufficiently numerous over limited areas to do considerable injury to crops.

The Two-striped Locust, although it enjoys so wide a range, is usually limited over this range to certain favorite haunts. Like the *femur-rubrum* and *differentialis*, *bivittatus* is a lover of rank and succulent vegetation such as is found upon bottom lands, along the edges of cultivated fields, at the margins of woodlands, and on the shaded mountain slopes. When nature has specially favored the species, as it sometimes does, in the way of favorable climatic conditions, the absence of enemies, etc., and it develops in large numbers, then these haunts are forsaken to a greater or less extent and it spreads over cultivated fields, eating the choicest of everything. Unlike some of the other locusts of the genus Melanoplus, *bivittatus* seldom exhibits the migratory habit in any marked degree; hence, is always with us and its enemies.

The egg-laying habits of *bivittatus* differ considerably from those of the smaller migratory species, insomuch as but one or two clusters or pods are deposited by a single female. Nevertheless, just as many eggs are laid by each female insect. These eggs are deposited in prairie sod or any compact soil in the vicinity of the regular haunts or feeding places. Old roads and closely-cropped pastures when located handily are favorite resorts for the heavily-laden females when attending to this mission of theirs.

Melanoplus bivittatus was very common in a number of localities over the country during the past summer. In fact, it was one of the principal ones that was the cause of grasshopper injuries in the Red River Valley of the North, in Iowa, Indiana, Ohio, Michigan, New York, Mississippi, Alabama, Kansas, and Nebraska. Conditions which favor the rapid multiplication of other locusts, such as the migratory kinds,

also favor the increase of this one and others of our "native" species. Hence when we hear of the increase and spread of the former, we may also look for the latter to become more numerous.

By keeping down weed patches and by plowing waste places about fence corners, along ravines, the edges of groves and old roads, this insect can usually be kept moderately scarce and harmless.

THE DETESTABLE LOCUST.

(*Melanoplus fœdus* Scudd.)

The locust which is known by the above name has not yet become recognized as one of those which is considered injurious; but its presence in unusual numbers during the past two years in portions of Idaho are sufficient grounds for including it with these injurious species. Even if it has not yet committed such devastation, it is apt to do so in the near future should climatic and other conditions continue favorable. It can at once be recognized from the accompanying illustration (Fig. 9) and the following description:

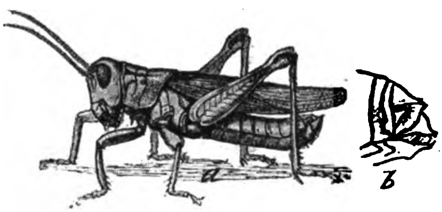


FIG. 9.—*Melanoplus fœdus*: *a*, male—natural size; *b*, female anal characters—enlarged (original).

Of medium, or rather large size. Head rather large, not elevated, slightly arched. Eyes pretty large, but not prominent; vertex between the eyes as broad or half as broad again as the first antennal joint; foveola shallow or moderate, with low, stout, nearly parallel bounding walls, and scarcely expanding in front; frontal ridge stout, well advanced, subequal, scarcely enlarged downward, above flat at the ocellus, and below a little and broadly sulcate. Pronotum simple, the posterior lobe coarsely and faintly punctate, expanding very slightly, and, on either side anteriorly, depressed a little above; the anterior lobe narrowed a little in front, but above only; both the transverse sulci equally distinct and continuous throughout, median carina slight and confined to the posterior lobe, lateral carinæ subobsolete. Tegmina extending a little, or considerably beyond the tip of the abdomen. Terminal ventral segment of the male abdomen scoop-shaped, but slightly produced at the apex, the edge entire; supra-anal plate triangular, bluntly pointed, considerably longer than broad, the sides nearly straight, slightly puckered in the middle; the marginal apophyses of the preceding segment consist of a wavy, depressed, conical, pointed projection diverging at nearly right angles, about half as long as the cerci. Anal cerci forming very simple compressed laminæ, the basal three-fifths straight, tapering a little and directed backward and a little upward, the apical two-fifths also straight, enlarging slightly, keeping the same direction but bent a little inward, the outer surface a little concave, the extremity squarely docked, its corners rounded; basal tooth of lower valves of the ovipositor of the female sharp, triangular, but much broader than long.

The general color is a dirty cinereous above, a dingy clay below; antennæ dull testaceous, becoming somewhat ferruginous toward the tip; a pretty broad and usually distinct blackish brown or piceous band extends from behind the eye along the upper border of the deflected lobes of the pronotum as far as the posterior sulcus, and sometimes as a blurred and expanded continuation of it, across the pos-

terior lobe also. Tegmina brownish cinereous, the anal field sometimes a little lighter, the median field enlivened to a greater or less extent, but seldom conspicuously, by an alternation of blackish and pallid longitudinal quadrate spots. Hind femora dirty clay brown with dusky incisures, above with a median and subapical dusky or dark fuscous patch; hind tibiæ red, with black-tipped spines.

Length of body—male, 24^{mm}, female, 30^{mm}; of antennæ—female, 12^{mm}, male, 13.5^{mm}; of tegmina—male, 21^{mm}, female, 24^{mm}; of hind femora—male, 14^{mm}, female, 16.5^{mm}.

This locust is in reality a mountain form that occurs at an elevation of about 5,000 feet above sea-level, and that frequents the edges of valleys and sunny slopes within the semiarid portion of the United States. It is met with in suitable localities in Colorado, Kansas, Nebraska, Wyoming, Utah, Nevada, Idaho, Montana, and the Dakotas, along with New Mexico.

Although the habits and life-history of this insect has never as yet been followed out, it is supposed that it does not differ materially from that of such other species of the genus as inhabit the same regions, and with which we are more or less familiar. In its general appearance and structure *M. fœdus* is very much like the insect which is known by the name of *Melanoplus packardi* Scudder. In fact there is but little difference save in color between the two species.

THE DEVASTATING LOCUST.

(*Melanoplus devastator* Scudd.)

Quite prominent among the destructive species of the country is the one known as the Devastating Locust of California. This particular species is of about the same size as the lesser migratory one, and has

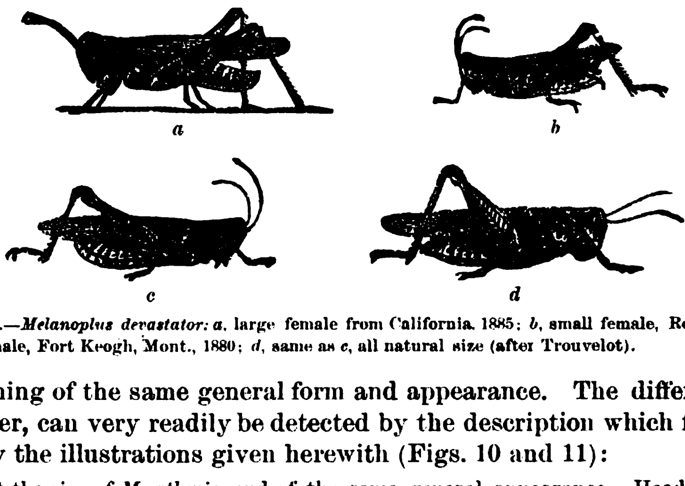


FIG. 10.—*Melanoplus devastator: a*, large female from California, 1885; *b*, small female, Reno, Nev., 1880; *c*, male, Fort Keogh, Mont., 1880; *d*, same as *c*, all natural size (after Trouvelot).

something of the same general form and appearance. The differences, however, can very readily be detected by the description which follows and by the illustrations given herewith (Figs. 10 and 11):

About the size of *M. atlanis*, and of the same general appearance. Head moderately large and broad, with large but not prominent eyes; vertex somewhat depressed, of medium width, quite deeply sulcate in the male, or but gently so in the female; frontal costa not very prominent but quite broad, the sides gently divergent below,

reaching to the clypeus, shallowly sulcate at the ocellus. Pronotum rather short and broad, slightly expanding on posterior lobe; median carina prominent throughout, cut about the middle by the last transverse impressed line; lateral carinæ also quite prominent and forming right angles with the disk and sides. Tegmina and wings reaching beyond the tip of the abdomen in both sexes, but quite variable in this respect, the former quite narrow. Last ventral segment of the male abdomen somewhat tapering, with the apex gently notched; super-anal plate triangular, the apex acute, middle narrowly grooved one-half its length; marginal apophyses of preceding segment about half as long as the supra-anal plate, tapering to a point, the inner edges attingent for about one-third their length, their outer edge furnished with a blunt tooth near the base; cerci slender, equal, straight, nearly four times as long as broad, the apex gently sulcate from the outside. Prosternal spine broad, stout, the apex rounded. Posterior femora reaching beyond the tip of the abdomen in both sexes.

General color light testaceous to dull cinereous, more or less varied with brown and dull black. Band back of the eyes very obscure, never continuous, but confined to

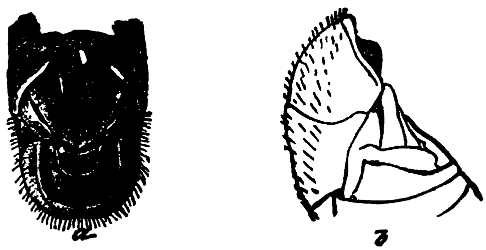


FIG. 11.—*Melanoplus devastator:* anal characters of male; *a*, from above; *b*, from side; *c*, from below—enlarged (after Emerton).

the upper edges of the lateral lobes as two small tapering patches and along the impressed lines. Tegmina provided with a row of discal quadrate spots and also usually a few others scattered above and below the central field. Posterior femora with the usual oblique dark bands; the hind tibiæ either dull red or various shades of green and blue more or less obscured with brown, usually greenish, the spines black.

Length of body (average specimens)—male, 20^{mm}, female, 22^{mm}; of pronotum—male and female, 5^{mm}; of tegmina—male and female, 18^{mm}; of hind femora, male, 12^{mm}, female, 11.5^{mm}.

Melanoplus devastator is known to occur at suitable localities throughout the entire region west of the main divide of the Rocky Mountains, and even to extend beyond this limit in portions of Montana and Colorado. Notwithstanding this rather extended range, the insect has never, to my knowledge, been reported in destructive numbers beyond the confines of California, Arizona, Nevada, and Oregon. Like several others of our North American insects that are included in this brief report, *devastator* is rather inclined to frequent the country adjacent to or among the foot-hills of mountain ranges. It does not usually deposit its eggs high up the hillsides and mountain slopes, but rather seeks for this purpose waste lands low down in the valleys that are more or less wet. Its growth and transformations are practically the same as those of *spretus* and the other species that have so frequently been described.

During the latter part of the dry season as the herbage and grasses ripen and dry up these insects gather from the surrounding hills upon the moist grounds at the margins of the valleys to feed upon the green vegetation still found at such places. Here also and close at hand the eggs for the spring brood are laid. Those for the fall brood are laid at random among the hills. In portions of California and Arizona there are two broods of this insect annually.* Wherever this is the case, there is considerable difference in the size and general appearance of the members that make up these two distinct broods. Those of the spring brood are larger and of a brighter color than those of the fall brood.

The difference in size and "freshness" in general appearance between individuals of the two broods in this and other double-brooded locusts is evidently due to the climatic conditions and to the nature of the food supply at different times of the year.

THE NARROW-WINGED LOCUST.

(*Melanoplus angustipennis* Dodge.)

Quite closely related to the preceding is another of our North American locusts of the genus Melanoplus which should be included with the destructive species. While this insect, which we will call the Narrow-winged Locust, has never yet, to my knowledge, been sufficiently numerous to materially injure cultivated crops or even the grasses on the prairies, it has been greatly on the increase for the past seven or eight years. As stated in a former report, "*Melanoplus angustipennis*, which only a few years ago was quite rare and confined to low land along the Elkhorn River, is now becoming quite numerous. If the species continues to increase as rapidly during the next four or five years as it has during the past few, it will be equally as destructive as *femur-rubrum*, *devastator*, *atlanis*, and *differentialis*. When first described it seemed to be confined almost exclusively to *Artemisia ludoviciana* as a food plant. Now it seems to take to almost any food plant that presents itself. This Narrow-winged Locust is more nearly related to *M. devastator* than to any of our other especially injurious species. Should it really become a pest, as present indications would suggest, its arboreal habit will render it rather a difficult enemy with which to deal.

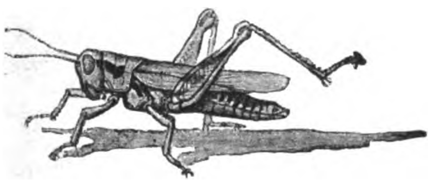


FIG. 12.—*Melanoplus angustipennis*—normal size (original).

* Mr. D. W. Coquillett in Bull. No. 27, Div. of Entomology, U. S. Dept. of Agriculture (p.39), states that he has taken both forms of this species in August, 1891, and believes the species to be single-brooded, and not double-brooded, as stated by Mr. Bruner.—C. V. R.

The following description is that given by the author of the species:

Frontal costa depressed at the ocellus. Head but slightly elevated above the pronotum. Foveola of the vertex scarcely depressed. Carinae of the pronotum nearly obsolete; the median cut by the three transverse incisions. Hind lobe of pronotum slightly rugulose. Tegmina extending beyond the abdomen, unusually narrow. Male cerci small, narrow, straight, tip rounded and sulcate. Tip of abdomen notched, as in *M. spretus* but the notch is wider.

General color light brown. Upper part of pronotum and hind femora with a reddish tinge. Face sometimes mottled. Antennæ light brown, infuscated apically. The usual black band behind the eye, broad and distinct, and reaching last division of pronotum, bounded below by a narrow white stripe. A broad white stripe from base of tegmina connects with a white stripe at insertion of posterior femora, forming a right angle. Outside of hind femora crossed by two indistinct dusky bands that extend upon the upper edge. Lower sulcation reddish. Knees black. Hind tibiæ blue. Tegmina light brown, with very small black spots in the disk.

Length of body—male, 22.5^{mm}, female, 24^{mm}; of tegmina—male, 17^{mm}, female, 19^{mm}; of hind femora—male, 12.5^{mm}, female, 14^{mm}.

As intimated above, this locust at first appeared to be one of the few species that are confined to special food plants; but now it has forsaken the single plant and takes up with a great variety of others. Since its food was originally the *Artemisia ludoviciana* its distribution was necessarily limited to regions where that plant flourished. With the change in its food habits so as to take in other plants it also was permitted to spread over more country. Now it occurs both on high and low lands, but appears to be somewhat partial to old breakings and well-fed pastures of many years' use. It occurs in eastern Montana, North Dakota, South Dakota, Iowa, Nebraska, Kansas, and Texas.

THE HERBACEOUS LOCUST.

(*Melanoplus herbaceus* Bruner.)

During the fall of 1887 the writer, while spending a few days at El Paso, Tex., took a large number of a rather large but slender Melanoplus upon various kinds of weeds and other low vegetation growing in the vicinity of the town along the banks of the Rio Grande. This locust was present in large numbers and did some damage. Like the *M. angustipennis*, it is rather an above-ground insect than a ground frequenter, and for that reason would be more difficult to fight, were it to become numerous, than are many others.

FIG. 13.—*Melanoplus herbaceus:* a, female—natural size; b, male anal characters—enlarged (original).

Aside from these few notes nothing further of its life history and habits are known to me, but it is presumed that the insect does not differ greatly from the species of the genus with which we are familiar.

The following description of the present species is herewith added,

that the insect can the more readily be determined by those who care to do so for themselves:

A rather large but slender species. About the size of *M. spretus*, but with much narrower wings and tegmina. Usually of a light transparent grass-green color, but changing to a dull olive brown in some specimens during late fall. Related to *M. flavidus*, *M. cinereus*, and *M. bowditchi*, from which species it differs in its smaller head and more oblique face.

Vertex between the eyes quite narrow, somewhat prominent, the foveola elongate spatulate, rather deep in the male, less so in the female, the lateral walls strong, rounded; frontal costa very broad and prominent above, less prominent below, where its sides converge very perceptibly in the female, parallel in the male, deeply and roundly sulcate from just above the ocellus (♀) or throughout (♂). Antennæ very long in both sexes, longest in the male. Eyes large and prominent, those of the male subelliptical, of the female with the anterior edges nearly straight. Pronotum rather slender, rounded above and with the sides nearly parallel or gradually widening posteriorly; anterior lobes plain, posterior lobe minutely and closely punctate; anterior edge nearly straight, posterior edge roundly angulate; median carina present only on the posterior lobe, lateral carinæ obsolete; transverse impressed lines plain, continuous, the last a trifle back of the middle. Tegmina and wings reaching beyond the tip of the abdomen in both sexes, the former rather narrow, lanceolate. Terminal segments of the male abdomen but slightly enlarged, gently upturned; the last ventral segment prow-shaped, the outer edge entire; supra-anal plate subquadrate, the lateral edges raised and somewhat sinuous, the apex gently depressed and slightly produced; in the middle there is a broad median carina terminating between two shorter ones near the apex; marginal apophyses of preceding segment very large, broad and fleshy, covering fully one-half of the underlying supra-anal plate, their inner edges touching for the first two-fifths of the distance from their bases and again at their apices, leaving a small, narrow, elliptical opening, their outer edges parallel, obliquely docked at the apex. Anal cerci a little more than twice as long as the basal width, the apical half finger-like, plain, the apex rounded, directed backwards and slightly inwards. Prosternal spine conical, rather long and slender, the point directed gently forward. Posterior femora normal, not quite reaching (♀), or slightly suppressing (♂) the tip of the abdomen; anterior and middle femora but very little enlarged in the male.

General color varying with the season and in different individuals from light grass green to dull olive brown, varied beneath and along the sides of the face, pronotum and thorax with dull white, yellow, and brown. The usual piceous band, which in this species reaches to the last transverse incision, is more or less plainly visible along the sides of the pronotum in different individuals. The tegmina are either pale green, dull olive, or drab, without spots; the wings with the apical veins and nerves more or less infuscated. Posterior femora without indications of bands along their upper edges and outer faces, a rather wide whitish line along the lower edge of the outer face, and also a tinge of light orange yellow below and on the inner face; posterior tibiæ deep sea-green, the spines with their extreme tips black. Antennæ reddish inclining to brown apically.

Length of body—male, 22^{mm}, female, 28.5^{mm}; of antennæ—male, 13^{mm}, female, 11^{mm}; of pronotum—male, 5^{mm}, female, 6.15^{mm}; of tegmina—male, 20^{mm}, female, 24^{mm}; of hind femora—male. 12.2^{mm}, female, 15^{mm}; of hind tibiæ—male, 10^{mm}, female, 13^{mm}.

The present species is confined to the river bottoms in the comparatively arid regions of our southwestern States. and also occurs across the line in Mexican territory for some distance.

THE ROCKY MOUNTAIN LOCUST.

(*Melanoplus spretus* Thos.)

Of all our destructive locusts native to North America this is the one that has caused the greatest amount of damage, and consequently attracted to itself the general attention of the public. It is likewise the best known when life-history, range, habits, etc., are considered. As already mentioned, its distribution is so well known that it is only necessary to refer to this feature here. In Bulletin No. 25 of the Division of Entomology, a brief, but at the same time, very comprehensive account of this and several other locusts is given. The reader is therefore referred to that publication for a more complete treatise upon the species now under consideration, also to the reports of the U. S. Entomological Commission for an extended account of its life-history and habits.

Briefly, the Rocky Mountain Locust can be said to be a permanent resident of the Rocky Mountain region from northern New Mexico northward as far as the North Saskatchewan River, or coincident with the northern limits of the prairies. This range also extends out upon the adjoining plains, and beyond, so as to include the greater portion of Wyoming, a little of northwestern Nebraska, more of the western part of South Dakota, nearly half of North Dakota, and much of Manitoba and other parts of British America west of Lake Manitoba. Of course the insect is not always to be met with in destructive numbers over this entire region; but it is within these limits that it is always to be found in a healthy condition. Adjoining this "permanent" region on the east is a strip of country of varying width of a hundred or more miles, that is termed the "sub-permanent" region. The insect is nearly as healthy and possibly equally as often to be met with here as in the permanent region. Beyond this secondary habitat is a still greater extent of country which is only occasionally visited by the moving swarms of the locust. This last region has on that account been termed the "temporary" region. This temporary region covers all of the remaining portions of the States mentioned above, besides extending into Minnesota, Iowa, Missouri, Kansas, Arkansas, Indian Territory, and Texas. This region is the one that has suffered most during past years from the ravages of this locust.

The description of this insect is herewith appended:

Female.—The face nearly perpendicular, sloping under toward the breast very slightly. The vertex between the eyes the same width as the frontal costa just above the ocellus; that portion in front of the eyes more or less distinctly channeled and deflexed at an angle of about 40 degrees from horizontal. Eyes nearly straight in front, about semicircular behind. Antennæ quite slender, reaching little if any beyond the tip of the pronotum. Pronotum, with the sides of the anterior lobes parallel, the posterior lobe expanding rapidly backward; median carinæ thread-like, but always distinct on the posterior lobe, usually obsolete on the anterior lobes; lateral carinæ obtuse but distinct on the posterior lobe and usually

so on the middle one, but becoming obsolete toward the front; posterior lateral margin, perpendicular from the humeral (entering) angle one-third the way down, then curving forward to the posterior lateral angle which is obtuse and rounded; the (entering) humeral angle is sharply defined, and in this respect differs from *M. femur-rubrum* and *M. atlanis;* the apex is obtuse-angled (about 100°) rounded at the point; posterior lobe minutely and shallowly punctured throughout; the anterior lobes smooth with a few or no punctures except along the lower margins of the sides. Tegmina and wings extending beyond the tip of the abdomen from one-fourth to one-third their length; the tegmina are of nearly uniform width throughout, slightly curving upward at their extremity; wings a little shorter than the tegmina, very thin and delicate; nerves and nervules very slender. Abdomen, and in fact the whole insect more slender than usual in this genus; but this appearance is partly due to the elongated wings; cerci very small, triangular or tooth-shaped, not extending across the segment on which they rest; valves of the ovipositor quite prominent, especially the upper pair which are more than usually exserted, sharp at the tips and deeply excavated above. The posterior femora usually extend to or about to the tip of the abdomen.

Color.—Reddish brown with fuscous spots. Head and pronotum back to the posterior sulcus, reddish brown, varying in depth of color in individuals; the face sometimes of a lighter and brighter red than the pronotum, sometimes darker, assuming a dark purplish hue; the posterior lobe of the pronotum is generally a pale olive brown, its lighter color contrasting somewhat distinctly with the darker shades of the anterior portion. Some individuals exhibit much lighter colors than here described, varying from dark brown to a dull yellow. The dark line on the side of the head and pronotum, usually so conspicuous in the closely allied species, is generally obliterated in this species by the dark-brown color; but it usually appears distinctly in specimens which have been immersed in alcohol, and is also manifest in the pale individuals, but is broken up by pale spaces and lines, and is rather narrow; the eyes, shining black; tegmina, ash brown, more or less tinged with reddish brown at the base and fading toward the apex; in the middle field, commencing near the base, where this field comes to a point, is an irregular row of fuscous dots, usually single to where the thin portion commences, now and then a double dot appearing; from this point to the apex they decrease in size and distinctness, and spread over the entire width; as a general rule the inner field is marked with a few fuscous dots; in some individuals a few quite distinct are seen, in others they are very minute and dim, and not unfrequently they are entirely wanting. Wings transparent, with a very slight yellowish tinge at the base; nerves and nervules of the costal area and apex black; rest pale. The abdomen is generally a glossy brown, with the posterior margins of the segments pale; venter yellowish or pale brown; sternum pale brown or yellow; anterior and middle legs usually rufous, but varying from reddish brown to pale honey yellow. Posterior femora with the disk reddish brown, sometimes showing dim outlines of oblique bands; the inner face and lower carinæ yellowish, the latter usually tinged with red; the upper carina and upper portion of inner face yellowish, marked with three large black spots or partial bands—one at the base, the other two equally spaced in the middle area; apex or knee black, or with a black crescent each side. The posterior tibiæ vary in color from bright red to pale yellow, and in some cases to bluish.

Male.—Differs from the female as follows: Is somewhat smaller and shorter, but the wings are about as long as those of the female; the abdomen is enlarged or widened posteriorly and strongly curved upward at the apex; the last ventral segment being elongated, rounded and narrowed upward like the prow of a boat, and is distinctly notched at the tip, the lips or lobes somewhat tubercular in form. This part of the apical segment is covered with minute scattering hairs. This notch forms one of the chief characteristics of the species, at least the most important one in distinguishing it from *femur-rubrum*. The supra-anal plate or triangular piece above the anal opening is sharply bicarinate longitudinally; the tooth-like append-

ages at the base, above, are narrow and slender. The cerci are somewhat longer than the width of the preceding segment, are broad and flat throughout, the width equalling two-thirds the length, not suddenly narrowed or constricted, moderately curved upwards and inwards; roundly narrowed and depressed at the apex. The prosternal spine (in both sexes) is subquadrate and large at the base, but distinctly transverse; robust and decidly conical, gradually lessening to a blunt point.

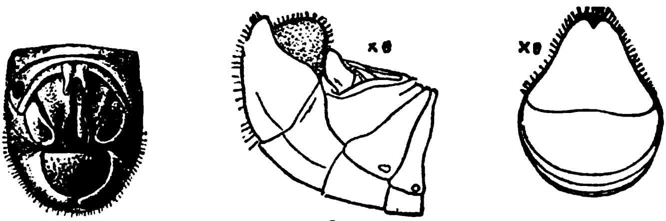
Dimensions: Length of body—male, 22–24^{mm}, female, 25–27^{mm}; of tegmina—male 24–26^{mm}, female, 25–27^{mm}; of hind femora—male 12^{mm}, female, 14^{mm}.

THE LESSER MIGRATORY LOCUST.

(*Melanoplus atlanis* Riley.)

Next to *Melanoplus spretus* this is the most destructive of our North American locusts. It is the insect that has been known to devastate portions of the New England States at various times during the past hundred years. It has also been known to occur in destructive numbers in various parts of the interior, but chiefly northward.

This Lesser Migratory Locust, as the name implies, is somewhat smaller than *spretus*, to which it is much more closely related than to any of the other destructive locusts described in the present paper. It is to be distinguished from that species by such characters as are shown in Fig. 14; and also by its proportionately shorter and narrower wings.



a b c

FIG. 14.—*Melanoplus atlanis*: anal characters of male; *a*, from above; *b*, from side; *c*, from behind, enlarged six times (after Emerton).

As is also implied in its name, it is migratory in habit, but to a much less degree than is *spretus*. In its distribution *atlanis* enjoys a much greater range than does the preceding, and for that matter, perhaps, than any other of our North American locusts, unless it be the *femur-rubrum*. While it occurs over such an extended territory, it appears to be more partial to hilly or mountainous regions rather than elsewhere. It seems also to prefer a wooded or mixed country to the open prairie or plains. It is common in all suitable localities from the Mexican boundary to the 53d degree of north latitude, and even beyond—in some instances nearly reaching the Arctic Circle—while it occurs both along the Atlantic and Pacific coasts.

The following original description, along with the illustrations referred to above, will at once enable the readers to distinguish the species from all others of our North American insects of this family:

At once distinguished from *femur-rubrum* by the notched character of the anal abdominal joint of the male and by the shorter, less tapering cerci; also by the greater

relative length of wings which extend on an average nearly one-third their length beyond the tip of the abdomen in the dried specimens; also by the larger and more distinct spots on the wings—in all of which characters it much more closely resembles *spretus* than *femur-rubrum*. From *spretus*, again, it is at once distinguished by the smaller size, the more distinct separation of the dark mark running from the eyes on the prothorax and of the pale line from base of wings to hind thigh; also by the anal joint in the male, tapering more suddenly, and by the two lobes forming the notch being less marked. From both species it is distinguished not only by its smaller size but by the deeper, more livid color of the dark parts, and the paler yellow of the light parts, the colors thus more strongly contrasting.

Just as the typical *femur-rubrum* is at once distinguished from the typical *spretus* by the characters indicated, so *atlanis*, though structurally nearer *spretus*, is distinguished from it at a glance by its much smaller size and darker, more marbled coloring. The contrast is all the greater in the living specimens, and I have seen no specimens of *spretus* that at all approach it in these respects.

Length of body—male, 17.5–21^{mm}, female, 19–23^{mm}; of hind femora—male, 11–12^{mm}, female, 12–13^{mm}; of tegmina—male, 19–23^{mm}, female, 20–24^{mm}.

As would naturally be expected, if one judged from its wide distribution, this particular locust presents some variations in its size, color, and to some extent, also, its structure, but not sufficiently so to render the identification of such forms at all difficult.

In regions where *M. atlanis* and one or two other species of the genus are double brooded, there is a very perceptible difference in the individuals of these broods, both in size and color. Both *atlanis* and *devastator* are notable examples of this kind. In California it is a common occurrence to find the latter insect during October and November apparently only recently fledged, but not much more than one-half the size of spring-reared individuals. Likewise, in the vicinity of Washington, D. C., late every fall numbers of very small *atlanis* are to be met with. These dwarfed specimens are always darker colored than the typical specimens of the early or spring brood; and they also frequently have the hind tibiæ glaucous instead of red as in *atlanis*. I have also seen fall specimens of southern *femur-rubrum* with the hind tibiæ glaucous instead of red. Several of our other Melanopli, as for example, *Melanoplus minor* Scudd. and *M. packardi* Scudd., also have these parts either red or bluish green. My collection also contains specimens of the large *Melanoplus differentialis*, from California and Arizona, with red hind tibiæ. A few of our species of locusts also have the tegmina and wings quite variable in length—some instances occurring where these appendages are quite rudimentary, or else, in other specimens of the same species, are fully developed. Wing length and color of hind tibiæ do not, therefore, indicate difference in species.

THE RED-LEGGED LOCUST.

(*Melanoplus femur-rubrum* De Geer.)

The common Red-legged Locust (*Melanoplus femur-rubrum*) is probably the most generally and widely distributed insect of this family in America. It occurs from ocean to ocean and from the extreme north-

ern range of these insects to Central America. Unlike several others of our destructive locusts that are limited to moderately high altitudes, this one is a frequenter of low elevations ranging from near sea level to not much over 6,000 feet above. This is true with reference to it within the limits of the United States, but in Mexico I have taken it at altitudes of 8,000 feet and upwards. Although it is found over so great an extent of territory, it occurs only at certain suitable localities within these boundaries. Its distribution appears to be controlled altogether by climatic conditions, the chief of which is the presence of a certain amount of humidity. Like *bivittatus* and *differentialis*, it is a frequenter of low grounds, cultivated fields, shady margins of woods, etc., where vegetation is rank and tender. On account of these peculiarities in connection with its naturally wide distribution, it has become our commonest locust in the United States.

The breeding habits of *femur-rubrum* are such as to especially aid the insect in its life among cultivated fields, and hence it is that it has become such a general nuisance. Were it not so generally preyed upon by a great number of different birds, mammals, reptiles, and predaceous insects, as well as by several parasites, it would be a much greater pest than it is.

It can readily be recognized from the following description and illustration (Fig. 15):

As compared with *spretus* the only very marked difference between the females is the shorter wings of this species, yet there are other slight differences observable when a large number of specimens are compared. The eyes in *femur-rubrum* are slightly more prominent. The head, pronotum, and sides of the thorax are usually some shade of olive brown, varying from pale to almost black. The black line behind the eyes is quite broad, seldom broken up, and is distinct in the darkest specimens. The humeral (entering) angles of the posterior margin of the pronotum are more rounded and not so sharply defined as in *spretus;* the median carina is usually more distinct on the anterior lobes, while the lateral carinæ are rather more obtuse and not so well defined; the punctures on the posterior lobe are more distinct. The wings extend but slightly beyond the extremity of the abdomen, usually less than one-tenth their length. In this species and *atlanis* the intercalate vein is present in the tegmina dimly and imperfectly, it is true, but it can be clearly distinguished for more than half the length of its course. In *spretus* it is wanting, its place being marked by the line of union between the two rows of cells. The fuscous spots or dots are not so conspicuous or widely spread over the apical portion of the wing, and the tegmina are narrower and straighter. As a very general rule the external face of the posterior femora is black or brown, the lower margin and lower half of the inner face bright coral red; when these colors are well defined there is a yellow space or stripe between the red and black, but these markings are subject to considerable variation, the red being sometimes entirely wanting, the external face dark, and the lower margin yellow; sometimes the dark is replaced by pale olive. The tibiæ are most generally bright red, but this character is not without exceptions. Usually there is a pale ray extending from the base of the wings to the posterior femora, but is occasionally wanting in dark specimens, and is generally absent in *spretus*. The prosternal spine is not so distinctly quadrate

FIG. 15.—*Melanoplus femur-rubrum*—natural size (after Riley).

at the base as in *spretus*, transverse, flattened behind, and not regularly conical, but somewhat subcylindrical to the broadly rounded and very blunt apex.

Male.—The most constant differences between the species is found in the form of the last ventral segment of the male; in *femur-rubrum* this segment, although strongly curved upwards, as in *spretus*, is not so distinctly narrowed toward the end, but rounded, and, instead of being notched toward the end, is squarely truncate, presenting a sharp horizontal and almost semicircular margin. Below the tip, on the posterior face of the segment, is a rather large, transverse, gash-like indentation. The cerci are about the same length as those of the male *spretus*, and about the same width at the base. The little tooth-like appendages at the base of the supra-anal plate are elongate and slender, as in *spretus*, and are sinuate.

In addition to the characters mentioned in the original description of *atlanis*, I would call attention to the following differences between it and *spretus* on the one side and *femur-rubrum* on the other.

Female.—As compared with the female of *spretus* the wings are shorter, extending but very slightly beyond the tip of the abdomen, not differing perceptibly in this respect from *femur-rubrum*; the tegmina are narrower, curved upward very slightly at the apex, very few spots or dots on the apical portion, and these minute and dim; the inner field is always immaculate; the posterior half of the intercalate vein apparent. The wings pellucid, but, when living, have, next the base, a bluish-white tinge; a larger portion of the pronotum nearly always dark. The black stripe on the side of the pronotum nearly always apparent even in the darkest individuals; head and anterior lobes of the pronotum with the velvety appearance so marked in *spretus*, but here dark or olive-brown without the reddish tinge so common to that species; the pale, oblique, metathoracic ray usually apparent but often obliterated.

For further differences between this and other species of our destructive locusts, see ante, under the description of *atlanis* and *spretus*.

Unlike the Lesser Migratory Locust and the true or Rocky Mountain Locust, *femur-rubrum* seldom exhibits the migratory trait in a marked degree. True, it will sometimes gather in immense "swarms" and move in concert, but it never rises to great heights, drifting with the wind as do the others. The "kerosene pans" or "hopper-dozers" are admirably adapted as implements of warfare against this locust, even after it has acquired wings.

THE LEAD-COLORED LOCUST.

(*Melanoplus plumbeus* Dodge.)

This hopper approaches more closely to the common red-legged species than to any of our other locusts belonging to the genus Melanoplus; but it is very readily distinguishable from that species by its bright colors and by its more clumsy movements. In its distribution, however, *plumbeus* is confined to the plains of Wyoming, Colorado, Nebraska, and probably also of Kansas; but it is not generally distributed even here, being confined to limited areas in certain localities where it is quite common.

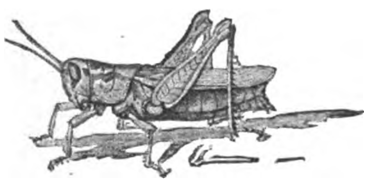


FIG. 16.—*Melanoplus plumbeus*—natural size (original).

Several years ago I found it quite abundant at a point about two miles south of Canyon City, Colo., so abundant, in fact, that, had it been

upon cultivated grounds, it would have injured the crops. But as it was confined to the gravelly bench lands no apparent damage was done by it.

The description of this locust as published by Mr. Dodge is as follows:

Frontal costa sulcate only at ocellus. Vertex slightly sulcate. Median carina of pronotum distinct, cut about the middle by last transverse furrow. Hind border of pronotum angled. Tegmina and wings extend beyond the abdomen. Cerci broadest at base and straight until near the apex, when they bend upward, and end in a blunt point. Tip of abdomen rounded.

Color, dark, inclining to blue. Pronotum with a red, longitudinal median stripe. Black band behind the eye, broadest on pronotum, ending at last sulcus. Yellow spots behind the eye on both sides of black stripe and below the same on side of pronotum. Cheeks bordered behind with yellow. Sometimes face yellow, mottled with blue. A yellow spot at base of antennæ, and a yellow stripe following the lateral carinae of pronotum on hind lobe, runs obliquely across base of tegmina to insertion of hind femora. Tegmina brown, with a few dusky dots along the disk. Wings tinged with blue. Upper outside face of hind femora dark blue, the upper edge crossed by the usual dark bands. Hind tibiae red with black spines. Antennæ light red. Entire under side of insect yellow.

Length of body—male, 21.5^{mm}; female, 25^{mm}. Of tegmina—male, 18^{mm}; female, 20^{mm}. Of hind femora—male and female, 12.5^{mm}.

PEZOTETTIX ENIGMA *Scudd.*

There is a normally short-winged locust throughout the region comprised of the States of Idaho, Nevada, Washington, Oregon, and California, which is often very abundant. In fact, it is to be classed among the destructive locusts of the country, since it appears to be quite plentiful if not numerous at all times and wherever it occurs.

This locust was described by Mr. Scudder as *Pezotettix enigma.* At about the same time he also described a long-winged form from the same locality that differs but little from the *enigma* save in length of wing. He called the long-winged insect *Melanoplus collaris.* Sometime prior to this Cyrus Thomas described the same insect under the name of *Caloptenus flavolineatus.* Since the short-winged form is apparently the typical condition under which the locust now under consideration occurs, the name *enigma* will best serve as that for the species.

FIG. 17.—*Pezotettix enigma* male—natural size (original)

The following description of the insect is that given by Scudder:

Pale brownish yellow, marked with darker brown and fuscous. Head large, tumid, all the angles rounded, the summit darker, with a sometimes inconspicuous median blackish stripe, broadening from in front backward; vertex between the eyes narrower than (♂) or equal to (♀) the frontal costa; fastigium very broadly and shallowly sulcate, most distinctly in the male; frontal costa broad and equal, very faintly punctate, with a scarcely perceptible narrow sulcus below the ocellus;

antennæ slightly infuscated at the tip. Pronotum short and rather stout, the anterior and posterior halves of the deflected lobes nearly symmetrical; dorsum with equal sides, quite distinctly tumid on the dorsum of the anterior lobe, the middle transverse sulcus nearly as close to the prosterior sulcus as to the short one in front of it, and the posterior lobe fully three-fourths the length of the anterior; posterior margin angularly rounded; median carina, like in the preceding species, marked in form like all the transverse sulci; dorsum mottled with dark brown, the lateral carinæ marked with a more or less distinct narrow yellow stripe; the anterior margin of the deflected lobes clear yellow or pallid; prosternal spine straight, small, conical, bluntly pointed. Tegmina rather broad, ovate, overlapping, the tip scarely produced, fully half as long as the abdomen, brownish fuscous, marked with yellow longitudinal veins, and flecked, principally along the median area, but also elsewhere, with longitudinal series of subquadrate blackish fuscous spots; wings a little shorter than the tegmina. Hind femora stout and full, yellow, the outer face marked with alternate, narrow, angulate, yellow and black stripes, often fainter in parts than in others, so as to show a tendency to transverse bands arranged as in *P. jucundus;* outer arc of genicular lobes broadly black; hind tibiæ yellow or greenish blue, the apical half of the spines black; arolium of either sex as in the preceding species (that is, either quadrate, rather narrow, longer than the claws (♂), or obpyriform, small, but little more than half as long as the claws (♀). Abdomen yellow, the upper portion infuscated, the middle of the dorsum marked frequently with a series of approximate, subdorsal, roundish, black spots, often inclosing white spots nearly as large as themselves, those of opposite sides separated only by a slender yellow line; the abdomen of the two sexes has the peculiarities of the preceding species (*Pez. jucundus*), the last joint of the male being also entire; the anal cerci of the male scarcely differ from those of that species, the slender apex only being a little less suddenly contracted.

Length of body—male, 22.5^{mm}, female, 24.4^{mm}; of antennæ—male, 9.25^{mm}, female, 7.5^{mm}; of pronotum—male, 6^{mm}, female, 6.9^{mm}; of tegmina—male, 8.25^{mm}, female, 10.75^{mm}; of hind tibiæ—male, 12.5^{mm}, female, 13.5^{mm}.

The habits of this locust are not yet very well known, since it has not been among the few species that have been made the theme for special study. In 1890, this insect was first seen by me in the central part of Idaho, about Shoshone and Boise City, where it occurred in large numbers along with *Camnula pellucida*, *Dissosteira obliterata*, *Melanoplus fœdus* and *M. atlanis.* In ratio of numbers the *enigma* came next to *pellucida.* It was found to be partial in its distribution to the lower bench lands in and near cultivated fields. What its egg-laying habits are I can not say, since the females had not yet begun depositing, although many pairs of the insect were seen and taken in copulation about August 15. Judging from the structure of the terminal portion of the female abdomen, which is very blunt, I should suppose that rather loose, sandy, or loamy soil would be chosen for the purpose of deposition. Like most of the other destructive species, this locust always appears at its best during warm, dry seasons.

THE PELLUCID-WINGED LOCUST.

(*Camnula pellucida* Scudd.)

While the majority of the destructive locusts belonging to North America are members of the subfamily Acridinæ, we are not entirely without those which are classified in the subfamily Œdipodinæ. Of

the three species which are thus classed the Pellucid-winged Locust is the most important when taken according to the amount of injury that has been done by them. This locust is, and has been, a common destructive species in California, Nevada, and Oregon for a number of years; and more recently has occurred as such in Montana, Idaho, North Dakota, Minnesota, and Manitoba. It is found as a common species over a much more extended territory than that in which it has appeared as a pest, since it is found in Washington, Utah, Wyoming, Colorado, New Mexico, Texas, South Dakota, and the mountain districts of the Middle and New England States. This insect is rather a dweller of mountain valleys and high latitudes than of low elevations and southern climes. Still, its more recent actions would indicate that it is remarkably hardy, and that it quite frequently becomes acclimated in new regions. During the past ten years it has worked its way eastward from the valleys of the Gallatins across the divide into the valley of the Upper Yellowstone, and thence down that stream to its mouth, after which it has followed the Missouri to a point not far from Bismarck. It has also reached the extreme western part of Nebraska by following down the Platte River from the mountain districts of Colorado and Wyoming. Its range in British America is probably clear across the continent, and as far to the northward as the Peace River at least.

The insect is fairly represented at Fig. 18. Scudder's description is also given herewith:

Ash brown; face reddish brown; antennæ yellowish at base, dark brown toward tip; a triangular black spot behind eye, the apex touching it; a quadrate transverse black spot on the anterior upper portion of the sides of the pronotum; pronotum above, sometimes with a dark band down the middle; tegmina or wing-covers with the basal half dark brown, with small yellowish spots and transverse streaks, especially on front border; apical half clear, with dark brown rounded spots, prevalent along the middle, decreasing in size toward the tip; when closed, the upper surface is dark brown, with a rather broad yellowish vitta along each angle on the upper surface; wings pellucid, with black nervules; legs dark brown, the hind femora yellowish or reddish brown, with two or three rather broad diagonal dark brown streaks, dark at the apex; hind tibiæ yellowish brown, reddish toward the tip, with a very narrow, generally faint, annulation of dark brown at the base; spines tipped with black.

FIG. 18.—*Camnula pellucida*: *a*, female, natural size; *b*, anal characters of male, enlarged (original.)

Length of body, male, 16.25mm; of female, 25mm; spread of wings, male, 33mm; female, 40mm.

The habits and life-history of this locust are not so well known as are those of several others of our species, but can best be compared with those of *Melanoplus spretus*, which has so often been described. The eggs are laid in similar pod-like sacs in the ground, there being about 25 to 30 to the pod. More than a single batch are laid by each female, the intervals between the layings varying from eight days to

two weeks. These hatch early in the spring and develop by a series of five skin molts between the time of leaving the egg and the appearance of the perfect winged individuals. As a rule, *pellucida* prefers and remains upon damp meadow lands among the hills and mountains; but when it becomes unduly common it shows decided tendencies toward migrating, and then spreads out over the adjoining country into grain fields, garden, and pasture lands, just as do most of our other destructive species when they become excessively numerous. Thus far this locust can not be said to have shown a tendency to move in certain directions in preference to others at given times of the year, as does the Rocky Mountain or true Migratory Locust of the United States. A further study of the Pellucid-winged Locust will, without doubt, add many new facts in relation to its life-history and habits that we do, as yet, not know.

THE LONG-WINGED LOCUST OF THE PLAINS.

(*Dissosteira longipennis* Thomas.)

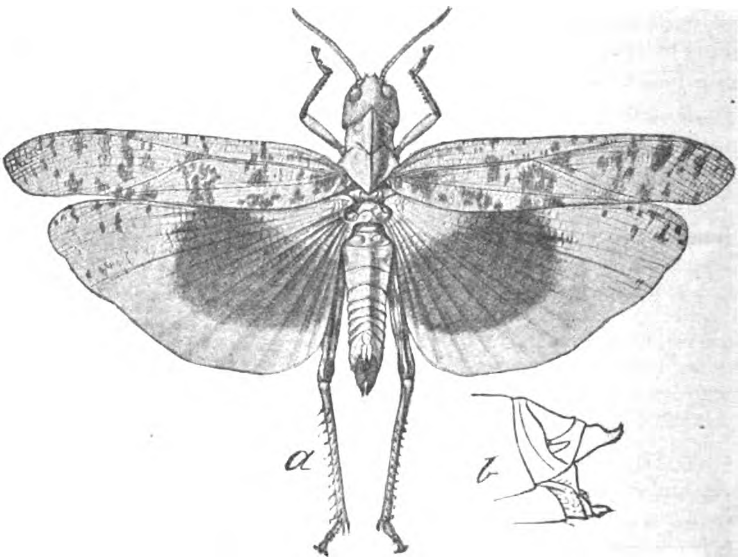


FIG. 19.—*Dissosteira longipennis*: *a*, female—natural size. *b*, anal characters—enlarged (original.)

Perhaps the greatest surprise to entomologists in the shape of injuries caused by locusts in this country was that occasioned during the past summer by the insect named above. Although it has been known to entomologists for twenty years, and has been twice described, this locust has been considered as belonging with our rarer representatives of the family of locusts. As stated in the preceding pages of this report, *longipennis* is rather restricted in its range, being found only upon the plains of western Nebraska, Kansas, southeastern Wyoming, eastern Colorado, and northeastern New Mexico, at an elevation of from 3,500

to 6,000 feet above sea level. It is also known to occur, for the most part, upon the gravelly slopes where vegetation is quite sparse.

During the autumn of 1876, when the true Migratory Locust was passing over the eastern part of Nebraska, a large specimen of this long-winged 'hopper was seen to alight at West Point, in that State, where the writer was at the time engaged in hay-making. It was captured and shortly afterwards described as *Œdipoda nebrascensis*. This is the only record of the insect having been taken so far away from its native region as since ascertained. Several years later, August, 1881, while spending some time in the vicinity of Greeley, Colo., this species was very frequently met with both to the northward and southward of the town, upon the bench lands, in company with *Tropidolophus formosus*, a very striking species of locust. Again, in 1889, while collecting specimens of various kinds in the extreme western part of Nebraska, a few individual specimens of this insect were taken; while, a year or two previously, it was obtained from Prof. F. W. Cragin, of the Washburn College, located at Topeka, Kans., who collected it in Barbour county, in that State.

FIG. 20.—*Dissosteira longipennis*: *a*, male—natural size; *b*, anal characters—enlarged (original).

This insect is well represented in the accompanying illustrations, which show it with and without spread wings, Fig. 19, being that with them spread, and Fig. 20 that in which it is shown with them closed. The following description will render its determination quite easy:

Tegmina and wings longer than the body; the former spotted with brown, the latter blue at base, but gradually becoming black toward the disk.

Vertex between the eyes broad; middle foveola circular, open in front with a slight median carina; frontal costa rather narrow, somewhat expanded at the ocellus, sulcate, expanding at lower extremity. Lateral facial costa nearly parallel with frontal. Median carina of the pronotum crested, as in *Dissosteira carolina*, only much higher; cut in front of the middle by last transverse incision of pronotum. Posterior part highly arcuate, anterior part nearly straight. Lateral carinæ slight, approaching a little in front of middle, where they are cut by two transverse incisions; then running parallel to median carina to base of occiput. Posterior margin of pronotum a little less than a right angle; the front margin advancing slightly upon the occiput. Tegmina moderately wide, slightly arcuate in front, nearly straight behind; about one-third longer than the abdomen. Wings about one eighth of an inch less, quite broad. Posterior femora not or but slightly channelled below, not quite reaching the tip of the abdomen in the female, or very slightly surpassing it in the male. Antennæ about as long as the head and pronotum combined.

Color brownish testaceous. Head and pronotum cinereous, with a greenish tinge. Clypeus lurid. Tegmina dirty yellow, spotted with brown, the spots on outer half running together so as to form irregular narrow bands; median vein brown half its length, bordered by yellow; spots on inner portion large. Wings bluish at base for about one-fifth their length, outer third yellow, sprinkled with brown spots at apex,

the disk black. Posterior femora crossed on the outer face by two light-brown bands; internally by two black bands. Apex black. Posterior tibiæ yellow, with dark spines. Venter yellow. Dorsum blue with a yellow spot on center of each of segments 1—4, remainder brownish. Sides brown, antennæ rufous.

Length of body—male, 28.5^{mm}, female, 43^{mm}; of tegmina—male, 31.5^{mm}, female, 47^{mm}; of posterior femora—male, 16^{mm}, female, 21^{mm}; spread of wings—male, 67^{mm}, female, 100^{mm}.

As would naturally be supposed, if we were to judge from the ample wings with which it is provided, this insect is an excellent flyer. It has shown a tendency to migrate during the past summer in Colorado, and is reported to have come into that region from the southward in 1890 prior to egg laying. These latter are deposited in the hard uncultivated ground in the localities most frequented by the mature insects. Whether or not more than a single cluster of them are laid by each female I have not yet ascertained. After hatching that spring, the young began feeding in droves, taking everything in the shape of grasses clean as they went; and at night, when not feeding, they clustered together upon the ground which they had bared. Although the insects were not so very numerous over the particular region examined by me, they nevertheless exhibited a decided desire for moving; still, they did not appear to want to leave the areas of bared ground above mentioned. Accordingly the country roads and edges of plowed fields were in great demand by them. During daytime the locusts would work out into the grasses for a few rods and feed, but as evening approached they reëntered the plowed fields, roads, and other spaces not covered with vegetation. Judging from what I had seen of the insect on former occasions, and knowing something of the habits and haunts of the mature form, I was led to believe that the great amount of rainfall and consequent luxuriant growth of vegetation over the entire region during the spring and early summer had much to do with the massing of this insect upon these bared areas. Even the bared areas about the nests of the red ant that builds the dome-like nests of small gravel of common in the region west of the one hundredth meridian, frequently formed centers about which droves of considerable size gathered. Such areas about ants' nests were frequently seen that had been enlarged to from several yards to a number of rods in diameter. Further to the southward, where Messrs. Snow and Popenoe had spent a week or more among the species, the insect was much more numerous and occupied the whole territory; hence these characteristics just mentioned were not so readily noticed.

The food habits of the Long-winged Locust of the plains appear to be rather limited, when compared to that of the Rocky Mountain and a few other species of these insects that are older acquaintances. Both my own observations and those of Messrs. Snow and Popenoe indicate that this insect is, so far at least, a decided epicure, and will only feed upon certain grasses native to that region where it occurs. These are the Grammas (*Bouteloua*) and the Buffalo Grass (*Buchloë dactyloides*).

Aside from these grasses, only a few instances are on record of its having injured cultivated crops, and these are only when the special food-plants had given out. Whether or not this same habit will continue, should the locust become habitually a pest, can not be foretold.

The habit of gathering or massing upon bared places, along with its clumsy nature, renders it an easy enemy to fight with the kerosene pans, etc. Hence, it can be easily controlled in future when desired.

THE PALE-WINGED LOCUST.

(*Dissosteira obliterata* Thos.)

Last year (1890) while investigating the Pellucid-winged Locust plague in central Idaho, a number of specimens of a large ample-winged species were observed among the *pellucida* in various places on the Shoshone side of the low mountain range lying between the Snake River Plain and the Camas Prairie. Upon capturing specimens of this locust it was found to be the insect which Prof. Cyrus Thomas described as *Œdipoda obliterata*. Later in the course of that expedition this same locust was met with in large numbers in the foothills lying to the south of Boise City. In that particular locality this, with two other species of locusts, had almost entirely denuded the ground of its covering of grass vegetation. The other species were the *Melanoplus fœdus* and *Pezotettix enigma*.

FIG. 21.—*Dissosteira obliterata*: *a*, male—natural size; *b*, female anal characters—enlarged (original).

Dissosteira obliterata also occurs in Oregon, Nevada, and California, in all of which States it is quite plentiful over limited areas. It is a very variable insect as far as color goes, and has been described under another name by M. Henri Saussure in his Prodromus Œdipodiorum. This name is *Dissosteira spurcata*.

Its habits, while not positively known, are supposed to be very similar to those of *Dissosteira longipennis*. It is a native of the semi-arid regions of the States where found, and frequents rather elevated, gravelly, or sandy hillsides where the vegetation is composed of various short grasses which thinly clothe the surface. When disturbed it rises from the ground with apparent ease and flits along on its ample wings to a considerable distance before realighting.

The following description will enable one to recognize it:

Male and Female.—Length to tip of tegima, 1.50; to tip of abdomen, 1.10 to 1.30 inches. Pale reddish-brown or dull yellowish, tinged with rufous, with irregular transverse bands of dark fuscous spots.

Occiput not prominent. Vertex broad, moderately deflexed margins, with sharp carinæ forming a distinct subquadrate, median foveola, which is divided into two equal sections by a distinct longitudinal median carina that extends back part

way upon the occiput; sides of the foveola parallel between the eyes, and bending abruptly inward toward the fastigium in front, continuous with the sides of frontal costa; fastigium with a double indentation. Frontal costa slightly sulcate, subtricarinate at the fastigium, widening at the ocellus, and extending nearly or quite to the clypeus, but not expanding below. In the male the width is about uniform throughout. Pronotum with the median carina subcristate, distinctly and deeply notched about the middle by the posterior sulcus; anterior portion irregularly arched, more elevated than the posterior portion, which has only the front part arched; lateral carinæ irregular and indistinct. The notch of the median carina is of the oblique type, more distinctly so in the male than in the female. Posterior lobe expanding rapidly from the posterior sulcus; nearly flat on the disk, which is more or less covered with elongate rugosities, more distinct and numerous in the female than in the male; posterior extremity obtuse-angled; anterior margin extended in a very obtuse angle upon the occiput. Tegmina extending about one-third their length beyond the abdomen, of medium width, sinuous, and obliquely excised at tip. Wings narrow, the length very nearly twice the width, and slightly undulate on the outer margin; the nervules unusually regular and straight. Posterior femora with sharp and elevated carinæ above and below. Antennæ rather short, scarcely flattened, and very slightly acuminated at the tip.

Color.—Female somewhat darker than the male; face pale purplish, dotted with fuscous; occiput and pronotum fuscous brown, the latter with a carneous stripe along each lateral carina, which connect at the anterior sulcus and fade out near the posterior extremity; the disk of the posterior lobe dark brown. Tegmina pale dirty yellow, slightly tinged with rufous, crossed by three irregular bands formed of dark fuscous spots, the middle one broadest and usually the best defined; apex with irregular cellular fuscous spots, those next the costal margin most distinct. Wings pellucid, with a narrow marginal, rather pale, fuscous band, commencing behind the subcostal area, where it is broadest, narrowing and fading toward the anal angle; the nerves and nervules, except in the apical portion of the subcostal area and in the fuscous band, pale yellow or white. Posterior femora crossed externally and internally by three oblique fuscous bands; posterior tibiæ pale yellow, spines tipped with black.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN No. 29.

REPORT

ON THE

BOLL WORM OF COTTON

(*Heliothis armiger* Hübn.).

MADE UNDER THE DIRECTION OF THE ENTOMOLOGIST

BY

F. W. MALLY.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., October 31, 1892.

SIR: I have the honor to transmit herewith, for publication as Bulletin No. 29 of this Division, a report by Mr. F. W. Mally upon the Boll Worm of Cotton (*Heliothis armiger* Hübn.), the first part covering his observations upon the parasites and natural enemies of the Boll Worm while the second part is devoted to his bacteriological experiments with certain insect diseases affecting this larva.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary.

LETTER OF SUBMITTAL.

WASHINGTON, D. C., *May 1, 1892.*

SIR: I submit herewith a report upon the remedies for, and the parasites and natural enemies of, the Boll Worm (*Heliothis armiger* Hübn.) covering the results of investigations carried on under your direction.

Respectfully yours,

F. W. MALLY,
Assistant.

DR. C. V. RILEY,
Entomologist.

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ACKNOWLEDGMENTS.

My first acknowledgments are due to Dr. C. V. Riley and to Mr. L. O. Howard, who have furnished valuable aid in the determination of specimens; to Mr. E. A. Schwarz for identifying Coleoptera; to Mr. Theo. Pergande for naming ants, and also to Mr. Nathan Banks, who was assigned to me in my work at Shreveport, for determining spiders.

The planters at Shreveport deserve great praise for their uniform courtesy, hearty coöperation, and the many sacrifices made in devoting time and labor to the promotion of field experiments. Those who assigned portions of their plantations for the sole purpose of testing remedial measures, and who therefore deserve personal mention, are Messrs. J. H. Fullilove, Daniel Nicholson, S. J. Ziegler, and John Caldwell, all of Shreveport; Mr. M. A. Curtis, of Curtis, La., and Mr. John Glassell, jr., of Rush Point, La.

The wide geographical distribution of the Boll Worm, and the different natural conditions in the various regions where it occurs, made it quite impossible to cover the entire ground without the assistance and coöperation of intelligent persons throughout those regions. Accordingly arrangements were made with the several State weather services to have their observers give special attention to any facts of interest and value to the investigation. This was accomplished through the efforts of the directors of the several services. Mr. M. G. Wright, jr., of Shreveport, La.; Prof. R. B. Fulton, University, Miss.; Mr. F. H. Clark, Little Rock, Ark.; Dr. J. M. Cline, Galveston, Tex.; Mr. George E. Hunt, New Orleans, La., and Prof. P. H. Mell, Auburn, Ala., merit special mention for their many favors.

While on a trip through northern Texas for the purpose of making special observations, much depended upon the assistance of observers in that section. It is a source of much satisfaction to state that no delay was experienced at any point, and that the work was facilitated in every way possible. At Mesquite, Tex., Messrs. S. G. Lackey and T. P. Worthington gave valuable information concerning their localities,

as did Mr. A. A. Pittuck, of The Texas Farm and Ranch, and Mr. F. Doremus, of the Dallas *Morning News*. At Arlington, Tex., similar courtesies were received from Dr. L. C. Page, Mr. C. F. Mercer, Capt. M. J. Brinsan, Col. J. A. Ditto, and Hon. J. W. Hammack.

Among those who by correspondence contributed freely of their experience, Messrs. S. B. Mullen, of Harrisville, Miss.; Jeff. Welborn, of New Boston, Tex.; John C. Edgar, of Duval, Tex.; Hon. George J. Twiley, of Holly Springs, Miss.; Prof. H. A. Morgan, of Baton Rouge, La.; Prof. J. G. Lee, of Calhoun, La., and many others, have my sincere thanks. Grateful acknowledgments are also due to Mr. Henry Hotter, Secretary of the New York Cotton Exchange; Mr. Henry Hester, Secretary of the New Orleans Cotton Exchange, for many favors, and to Mr. A. B. Shepperson, of New York, for "Cotton Facts" and general statistical information.

HABITS AND NATURAL ENEMIES OF THE BOLL WORM.

DESTRUCTIVENESS.

During May corn is practically the only abundant and available crop to be attacked by the Boll Worm. At that time a study of a number of corn fields on both bottom lands and uplands was made. The number of plants attacked was noted, as well as other data, as shown in Table I.

TABLE I.—*Ravages of Boll Worm on May corn.*

	Field.								Total.
	1.	2.	3.	4.	5.	6.	7.	8.	
Plants examined	377	296	472	720	422	496	511	368	3,662
Eaten	16	7	12	21	4	6	16	15	97
Not eaten	361	289	460	699	418	490	495	353	3,565
Worms	3	4	1	7	......	......	3	8	26
Half grown	2	1	1	2	......	......	1	......	7
Very young	1	3	......	5	......	......	2	8	19
Color:									
Dark	3	1	......	5	......	......	2	7	18
Green	......	......	......	1	......	......	......	......	1
Light green	......	3	1	1	......	......	1	1	7
Mashed:									
Half grown	2	1	1	2	......	......	1	......	7
Very young	1	8	......	4	......	......	1	7	16
Not mashed	......	......	......	1	......	......	1	1	3

It will be seen from this table that of the 3,662 plants examined, 97, or 2.6 per cent, showed injury, and 26, or 0.7 per cent, actually contained Boll Worms. Fields 5 and 6 were "hill country," and though plants were found apparently injured by Boll Worms, much of the damage done was due to *Prodenia lineatella*. The other fields were Red River bottom lands.

June 1 a study was made of a small patch of sweet corn, which was then in good roasting ears. The results are given in Table II.

TABLE II.—*Ravages of Boll Worm on sweet corn roasting ears.*

Ear.	Worms.	Size.			Color.			
		Grown.	Half grown.	Very young.	Dark.	Green.	Light green.	Rose.
1	6		3	3	6			
2	3		2	1	3			
3	2	2			1		1	
4	6	2	2	2	4		2	
5	3		1	2				
6	1	1					1	
7	5		3	2				
8	3	1	1	1	1		1	1
9	4			4				
10	3		1	2	2	1		
11	1			1	1			
12	1		1					
13	*12		3	*9	5	1	5	1
14	5		2	3	2		3	
15	6		3	3				
16								
17	2			2	2			
18								
19	1			1	1			
Total	64	6	22	36	28	2	13	2

* One dead.

On the same date a field of crop corn just tasseling was similarly studied. The number of plants examined is not given, but simply those upon which worms were found. The larvæ in nearly every case were found in the freshly protruded or protruding tassel. The facts are presented in Table III.

TABLE III.—*Worms found on tasseling corn.*

Plant.	Worms.	Size.			Color.			
		Grown.	Half grown.	Very young.	Dark.	Green.	Light green.	Rose.
1	1	1						1
2	3	2		1	2	1		
3	1	1				1		
4	2	1	1		1			1
5	2		2			1		1
6	1	1				1		
7	2		2		2			
Total	12	6	5	1	5	4	....	3

Much error prevails among planters as to the causes of the shedding of the cotton crop, and that much of the blame has been misplaced is shown by the following tables. The data upon natural shedding (Table IV) and the natural or normal average number of bolls matured by a cotton plant under favorable conditions (Table V) were noted in fields entirely free from Boll Worm ravages.

TABLE IV.—*Bolls in cotton plant—natural shedding.*

Plant.	Bolls in plant.	Shedding.		Total.
		Natural.	Other causes.	
1	71	25	22	118
2	16	16	17	49
3	157	52	16	225
4	68	36	3	107
5	26	30	4	60
6	70	33	10	113
Total	408	192	72	672
Average per plant	68	32	12	112

TABLE V.—*Matured bolls in cotton plant.*

Plant.	Bolls matured.	Plant.	Bolls matured.
1	25	9	12
2	16	10	17
3	18	11	22
4	26	12	31
5	25	13	33
6	22		
7	22	Total	286
8	17	Average per plant	22

Table IV shows that when examined September 7 plant 3 had borne a total of 225 and plant 4 a total of 107 squares, forms, and bolls; September 29 plant 3 bore only 98 bolls and forms, and plant 4, 59; October 10 plant 3 had 96 and plant 4, 51; November 14, plant 3 bore 83 and plant 4, 44. At this time it was evident that the bolls yet remaining would mature and open if conditions continued favorable. Hence, by natural agencies the original numbers had been reduced to 83 and 44, respectively, by November 14. The shedding of plant 3 was, therefore, 63.2; that of plant 4, 58.9 per cent. Even the figures given in Table IV on September 7 show that of a total of 672 bolls and squares originally borne by the six plants only 408 were then upon them, a shedding of 264 bolls, or 39.3 per cent. The plants examined were above the average in growth and vigor.

These facts should impress the planter reporting damages supposed to be due to an insect with the necessity of making a careful examination and discovering the real causes operating. If this be done, he will often find that much of his loss is due to perfectly natural causes and not to insect depredations.

The data contained in Table V are based upon average plants which had already matured, or at least had set their full crop. It must be noted in this connection that the average given applies to good cotton only, in such districts as northern Louisiana and Mississippi. In river bottoms, where cotton grows much more vigorously, the average per plant is proportionally greater. In some of the southern and central

portions of Texas, where cotton grows from 7 to 10 feet high, the average may be twice that given in the table. These facts are recited to illustrate the necessity of making local studies for a given locality in order to arrive at anything like an accurate estimate of the injury and loss for that locality.

TABLE VI.—*Condition of cotton field at Mesquite, Tex.*

Plant.	Bored.	Other causes.	Good bolls.	Total.
1	15	....	7	22
2	4	14	15	33
3	5	18	16	39
4	2	2	14	18
5	1	4	58	63
6	3	....	8	11
7	12	....	12	24
8	14	3	6	23
9	6	....	7	13
10	10	....	2	12
11	6	3	12	21
12	21	5	18	44
13	7	2	21	30
14	3	2	14	19
15	2	2	21	26
16	1	4	22	27
17	....	9	33	42
Total	112	69	286	467

TABLE VII.—*Condition of cotton field at Arlington, Tex.*

Plant.	Bored.	Other causes.	Good bolls.	Total.
1	7	5	11	23
2	1	5	25	31
3	1	....	21	22
4	1	1	12	14
5	1	3	25	29
6	12	14	23	49
7	....	5	30	35
8	3	2	15	20
9	9	1	22	32
10	8	6	16	30
11	1	2	13	16
12	7	5	14	26
13	2	....	11	13
14	4	2	15	21
15	13	9	12	34
16	23	15	43	81
Total	93	75	308	476

TABLE VIII.—*Early and late cotton compared.*

LATE COTTON.

Plant.	Bored.	Other causes.	Good bolls.	Total.
7........	12	....	12	24
8........	14	3	6	23
9........	6	....	7	13
10.......	10	....	2	12
11.......	6	3	12	21
12.......	21	5	18	44
13.......	7	2	21	30
Total ...	76	13	78	167

EARLY COTTON.

14.......	3	2	14	19
15.......	2	3	21	26
16.......	1	4	22	27
17.......	0	9	33	42
Total ...	6	18	90	114

Tables VI and VII exhibit data obtained while on a trip through the part of Texas which was worst infested by the Boll Worm. The figures for Table VI were noted at Mesquite, August 24, and for Table VII the facts were obtained at Arlington, August 27. In Table VI plants 1 to 6 inclusive were in the same field and stood consecutively in a row; plants 7 to 13 inclusive in a second field, consecutively as before; while plants 14 to 17 inclusive were taken at random in a third field. Plants 7 to 13 were in a field of late cotton, still blooming profusely at the time of observation; 14 to 17 were in one of early cotton in which all the fruit had set and which, therefore, contained but few blossoms at that time. These data are compiled separately in Table VIII for the purpose of comparison. It presents some significant facts concerning the question of early and late cotton in Boll Worm districts. Thus, of a total of 167 bolls of the late cotton, 76, or 45.5 per cent, had been injured by the Boll Worm; of a total of 114 bolls of early cotton, only 6, or 5.2 per cent, were injured. Estimating the difference upon the basis of the normal average, we have the following result: The seven plants of late cotton averaged 11.14 bolls per plant, and the four plants of early cotton 22 per plant, 22 being the normal average arrived at in Table V. The late cotton therefore shows a loss of 50.6 per cent, while the early cotton shows no real loss. This may be taken as an extreme case, but the general principle remains that late cotton receives by far the greater portion of the Boll Worm attack, virtually protecting the early cotton fields about it.

TABLE IX.—*Shed bolls found on ground.*

Table.	Plants inclusive.	Bored.	Other causes.	Total.
VI........	1-6 and 17	8	103	111
VI........	7-13	69	44	113
VI........	14-16	10	42	52
VII	1-9	40	44	84
VII	10-16	43	64	107
Total..	....	170	297	467

TABLE X.—*Good bolls per plant.*

Source.	Bored.	Other causes.	Good bolls.	Total.
Table VI .	112	69	286	467
Table VII	93	75	308	476
Table IX .	170	297	....	467
Total..	375	441	594	1,410
Per cent..	26.6	31.3	42.1	100

Table IX presents a study of the bolls and squares found shed and on the ground under the plants recorded in Tables VI and VII.

The totals of Tables VI, VII, and IX are arranged for convenience in Table X. From the facts thus presented it is found that 18 is the average number of good bolls per plant. The normal average has already been given as 22. Hence the loss from injury is 18.2 per cent instead of 26.6, as found by the usual method. This difference is largely due to having included the data of Table IX, which represents the shed bolls found on the ground under the plants examined. As has been shown by Table IV, many of these would have been shed by natural process, but were bored before having fallen. Hence, if included, they exaggerate the real damage. The actual damage should be estimated upon the basis of the average amount normally matured by the cotton plant in any given locality under favorable conditions. Omitting Table IX from Table X we have the following results:

Source.	Bored.	Other causes.	Good bolls.	Total.
Table VI	112	69	286	467
Table VII	93	75	308	476
Total ...	205	144	594	943
Per cent	21.7	15.3	53	100

The above percentages are obtained upon the basis of what was actually found upon the plant August 27, without reference to the number of bolls normally matured per plant for that locality. The per cent of damage is shown to be 21.7, which, compared with the 18.2 per cent obtained on the other basis, shows that this estimate is quite accurate and, for all practical purposes, satisfactory.

The damage detailed above was found only in the worse infested districts visited. In other localities the injury was much less, or none at all. Even in the infested districts some fields were found which had practically escaped injury. The estimated damage of 18.2 per cent applied more especially to a region approximately included by an imaginary line running from Paris, Texas, to Tyler, to Palestine, to Temple, to Greenville, to Paris. Other cotton-producing counties in Texas were much less affected, and for the entire State it will be safe to place the maximum limit of Boll Worm injury at 10 per cent, with probabilities that it is still less.

Along the Red River and Mississippi valleys, and, in general, in the bottom lands along the smaller rivers and creeks, the injury is greatest. In the greater portion of Louisiana and Mississippi the damage is certainly not over 2 to 3 per cent. In Arkansas the damage along the rivers and in a belt across the State from Little Rock to Fort Smith was more serious, and for a considerable portion of the State ranged from 10 to 15 per cent. This is due in part to the greater acreage of corn in proportion to that of cotton. The reason for this lies in the fact that a greater number of individual ears are produced, and hence the probability of a greater number of worms reaching maturity. The relation existing between the acreage in corn and the acreage in cotton is no objection to the trap-corn method, to be subsequently discussed, but rather makes it all the more advisable to use it at the proper time. In Alabama, Florida, Tennessee, Georgia, and the Carolinas the ravages are insignificant, and usually do not excite general attention. If the acreage and production of these States be included to ascertain the per cent of loss to the entire cotton crop from Boll Worm depredations, it is evident that the percentage will be reduced to a small figure.

Those who have never spent a season among cotton-planters may consider this discussion of damage peculiar or even unnecessary. The fact is that the average observer, whether planter or newspaper reporter, seldom comes to his conclusions upon a basis of what is found upon the plant, or after having considered natural causes of loss. He judges mostly by what he sees lying upon the ground, and to this, as has been shown, several causes contribute. Upon this basis (see Table IV) a damage of 39.2 per cent could be reported. Such reports are entirely misleading and erroneous, and have no foundation in fact. It is even more difficult to give an estimate of the damage to corn by Boll Worms. From Table I it is found that in May, 2.6 per cent of the young corn plants had been attacked. The plants were not ruined nor even checked in their growth, and ultimately produced sound ears of corn. The conditions presented in Table III are quite disgusting when viewing the ravaged tassels, but in the end the ear of corn is produced. Romantic discussions of these facts have been entirely misleading, and for corn it is safe to assert that no real damage is occa-

sioned, so far as the ultimate yield is concerned, by the depredations mentioned. The ravages in the ear at a later period do, however, occasion some loss. From a money standpoint this loss is perhaps felt most by gardeners growing sweet corn for early market. Badly infested ears must be thrown away and a greater acreage is therefore necessary to insure a sufficient supply of uninfested ears. How serious a matter this may be depends entirely upon the locality, and much the same may be said of the regular crop. Many of the ears have some of the grains damaged, and this, together with the excrement of the worms, makes them to a certain extent distasteful or undesirable for feeding purposes. But the most serious objection arises when the corn comes to the mills to be ground into meal. Technically the meal will be reduced in purity and standard quality, but this is after all only a theoretical objection, since the question is never raised or thought of when the meal is on the market, and its market value is not affected.

General estimates of insect injuries by per cents are misleading, and hence the advisability, in order to maintain scientific accuracy, of assigning to them only a local application or significance.

FOOD-PLANTS OTHER THAN COTTON AND CORN.

Tobacco.—The eggs of the Boll Worm are laid indiscriminately upon all parts of this plant. Tobacco leaves and very young portions of the plant are thickly set with plant hairs, which are covered with a sticky secretion. The eggs are usually found stuck fast to the tip of one or two of the hairs; not close to the surface of the leaf. The sticky hairs trap many small insects which crawl about them and even the newly issued Boll Worms are caught occasionally, and perish in the attempt to get away. The flower-buds and green seed-pods of tobacco are freely attacked, and large racemes sometimes have one-half or two-thirds of their fruit eaten into. Tobacco is topped to prevent its flowering and producing seed. The stem contains a succulent pith which the larvæ relish and they often eat down the stem from the broken and exposed end. As they go down, the leaf found at each node often withers and dies as they pass it. The small field of tobacco examined was several miles away from any cotton or corn fields. This partially explains the abundance of the Boll Worm in this isolated patch. They doubtless do not feed so extensively in regular tobacco districts. The important thing for the cotton-grower is to see that the topped portions, bearing so many eggs and young larvæ, are burned for the purpose of destroying them. The suggestion may be carried even further. The topping process practiced upon tobacco leaves only a minimum number of racemes for the production of seed. These remaining racemes were more thickly stocked with Boll worm eggs than anything else observed in Texas; in fact, nothing except fresh corn silk was ever found so thickly infested. This was on August 25, which is past the height of the flowering period of the earlier cotton. Small patches of cotton could therefore be planted

as trap crops, cutting off and burning the racemes when well stocked with Boll Worm eggs. In those portions of Texas which are subject to early and continued drought this method may be even more successful than that of trap corn.

Tomatoes.—The fruit of this plant is bored in the same manner as the cotton boll, as already discussed in Bulletin 24 of this Division. The worm also bores into the stems, sometimes cutting them nearly off in so doing. The damage is usually ascribed to cut-worms, and in the majority of cases, properly. Occasionally, after having eaten to the pith of the stem the larva goes downward, hollowing it out as it goes. This causes the portion of the plant above the point of injury to wilt or break and die. This sometimes happens to the central trunk of the plant and the whole of it is then ruined.

Other Food-plants.—Cowpeas and the pods of various kinds of beans and peas, are often found eaten full of holes, and the peas and beans devoured. Cucumbers, cantaloupes, and small watermelons, and okra pods are occasionally bored, but the attack is not general or extensive. Mr. W. J. Holland, Brewton, Ala., reports their boring into and feeding upon the stems of Collard. Red-pepper pods are occasionally destroyed. The wild Ground Cherry (*Physalis pubescens*) quite commonly has its berries eaten by this insect. In the vicinity of Mount Lebanon, La., Mr. T. W. Vaughan reports that during September fully one-half of the pods borne by the plants had been ravaged by it. Late in the season volunteer sorghum plants are often found with riddled leaves, some of which may be due to boll-worm attack, but in the majority of cases is attributable to cut-worms. A large Abutilon plant in an ornamental flower garden was freely deposited upon by Heliothis, nearly every flower bud and some of the leaves bearing an egg or two. The young larvæ did not relish this food-plant, and deserted it almost immediately. Probably the majority perished before finding suitable food. The leaves and very young flower buds of the Jamestown Weed (*Datura stramonium*) are sometimes eaten, as also the fruits of the Cockle Burr (*Xanthium strumarium*). The burs are attacked while very young and just forming, the usual method of injury being to eat into the tender peduncles bearing them. Some of the host-plants enumerated for the Boll Worm are doubtless accidental, for the larvæ do not thrive upon them.

CHARACTERS AND TRANSFORMATIONS.

These have been treated at some length in Bulletin 24 of this Division and only a few additional observations will be noted in this connection.

LARVA.

A marking not found in all specimens is a pinkish or pale orange colored spot on each segment at the upper edge of the subdorso-lateral stripe. The color may be inconstant for the same individual. For

example, a larva which was taken from a cornfield June 9, was uniformly green when placed with food in the breeding cage. June 12 it was noted as becoming yellowish, or at least could not be called green. Thus several color variations were noted during the larval state of the same individual. In most specimens the color remains quite constan.

TABLE XI.—*Proportion of light and dark larvæ.*

Source.	Date.	Light green.	Green.	Rose.	Dark.	Total.
Corn......	May 8	....	4	....	6	10
Do	May 9	6	17	....	10	33
Table	May 14-16	7	1	....	18	26
Do	June 1	13	2	2	28	45
Do	June 1	....	4	3	5	12
Total	....	26	28	5	67	126
		54		72		

Some facts relative to the proportion of light and dark-colored specimens are presented in Table XI. All the larvæ were taken from corn plants, tassels, and ears. Most of the green ones were about grown, the dark ones mostly small. The figures clearly show that for May and June the dark worms predominate, comprising about 57 per cent of the number. During July and August the proportion becomes about equal, while at the close of the season the light-colored specimens are in the majority.

The larvæ are very tenacious of life, as the following note will show: One evening an ear of corn containing a nearly grown Boll Worm was placed on end in a jar of water to keep it fresh until next morning. At that time the larva was found outside the ear in the water. To all appearances it was dead, and was so considered. Mr. Banks, however, placed it upon some dry earth in a saucer exposed to the direct sunlight, and the following day we found, to our surprise, that the larva was again becoming active. It was later provided with food, upon which it fed, pupating perfectly. To our disappointment, however, it died in the pupal state. Half-grown worms placed in the bud of young corn plants in breeding cages often bored the entire length of the stem to the roots. In several instances this left them an inch or two below the surface of the water in the vessel, but no harmful effects upon the larva were noted.

In attacking young corn the Boll Worm does not always feed in the the bud or heart of the plant, but occasionally takes a position on the outside of the stalk near the surface of the ground, eating inward as if into a boll. This done, the plant wilts and dies. When examined and found eaten nearly off, the injury is at once assigned to the work of cut-worms, and this is doubtless the true explanation in most such cases, but the exceptions should be noted. In the breeding cages, where young corn plants were kept fresh and growing in wet moss, a

larva in one instance left the plant and went entirely beneath the surface and fed upon the tender roots.

Many observations upon recently hatched larvæ in breeding cages proved that they feed reluctantly upon corn blades, except in the heart of very young plants. In their continued search for something better they nearly always perished. In the field very young Boll Worms are rarely found on leaves or husks, but always in the silks near the tip of the ears. This fact, taken in connection with laboratory observations, indicates that the larvæ hatched from eggs on the leaves and husks at once seek out the silks. Doubtless many perish before reaching the ears. They feed mostly upon the tender silks up to the time of the first molt, and later begin feeding upon the milky grains.

The larvæ sometimes come out from their ear of corn and either take position on the outside of that ear or go down to the stalk and there molt. Only a small number, however, have this habit, the majority molting without leaving the ear.

Upon cotton the newly hatched larva sometimes hides itself in a cluster of expanding leaf buds, fastens them together loosely with a few silk threads, and either feeds under the shelter of the young leaves or bores the peduncles and tender growing stems. So far as observed, this slight webbing occurs only previous to the first molt.

During spring and summer the Boll Worm undergoes its transformations more rapidly, and the intervals of molting are correspondingly shorter. The following record is an example:

Egg hatched June 11, 9 a. m. First molt, June 17, 9 a. m., six days after hatching. Second molt, June 18, p. m., or not more than one and a half days after the first. Third molt, June 20, two days after second. Fourth molt occurred at time of pupation, June 25, five days after the third. Length of larval state, fourteen and one-half days. The exact number of days between the molts varies slightly, but the general fact remains that the second and third molts occur in quick succession, while the first and last are often at much longer intervals. Before the first molt their growth is slow, but afterwards the rapidity of growth under favorable conditions is remarkable. During the period from the first to the third molts the larvæ feed incessantly from morning to night. Before the first and after the third molts occasional short intervals occur during which they may be found resting.

There is no question but that Boll Worms deliberately prey upon each other when they become numerous in ears of corn. Frequently an ear is opened and a larva found in the act of devouring another. These observations, however, had the objection that there was no record of the larvæ previous to the time of making them, and that therefore the victims might have been parasitized or diseased and unable to resist attack. Accordingly an ear containing three or four quite large Boll Worms was taken from the field and the worms were carefully examined as to parasitism or previous injury. They were then placed back

in the ear in a large breeding cage, care being taken not to excite the worms during the process. The second day following the ear was examined, and one of the larvæ was found feeding upon another, the third having been already devoured. This was a clear case, and no further observations were made upon this point.

PUPA.

When full grown the larva goes into the earth for pupation. The process of burrowing, making the cell, and pupating occupies about two or three days for the spring and summer weather. In October and November often ten days or two weeks are spent in the cell before pupating. The records of pupæ from some of the larvæ reared are tabulated for reference in Table XII.

TABLE XII.—*Record of observed pupæ.*

Number.	Pupated.	Issued.	Length of pupal state.	Color of larva.	Color of moth.	Earth.	Depth.
			Days.				
1	May 23	June 4	12				Surface
2	June 8	June 17	9	Rose	Olivaceous	Moist	
3	June 4	June 13	9		do	do	¼ inch
4	June 8	June 17	9	Green	Dark	Dry	
5	June 8	June 18	10	do	do	Moist	¾ inch
6	Missing.	June 20		do	do		⅞ inch
7	June 15	June 25	10	do	Olivaceous		
8	June 25	July 6	11	do		Moist	1¼ inches
9	June 15	June 24	9	do	Dark	do	
10	June 22	July 2	11	do	do	Dry	Surface
11	June 26	July 6	10	Rose		Moist	
12	July 17	July 26	9		Dark	(*)	
13	July 13	July 24	11	Green		Dry	Surface
14	July 22	July 31	9	do	Olivaceous	do	

* Wet moss.

The average length of the pupal state for the thirteen specimens recorded is ten days, with a range from nine to twelve days. For the months of May, June, July, and August this time is correct, but late in August, September, October, and November the length of the pupal state becomes variable. As an example of this variability may be recorded the following: Some eggs hatched August 26 and the larvæ fed until October 9, a larval period of forty-four days. October 9 two pupæ were obtained. One of these hatched December 12 of the same year, after a pupal stage of sixty-four days. The remaining pupæ issued May 1 of the following year, a pupal state of 203 days. In 1891 quite a number of larvæ pupated about the middle of October. Two-thirds of the number issued after a month, while some were kept over winter.

The manner of pupation is by no means constant. In the field the normal method is to burrow at an angle to a depth of 2 or 3 inches, then to form a cell upward from the end of the burrow. In this cell the pupa rests upon its posterior end in a vertical position. Loose earth sparsely webbed together partially fills the burrow for almost, if

not quite, its entire length. In breeding cages they sometimes pupate on the surface, either naked or by loosely webbing together some earth, making a frail cell. Sometimes the larvæ burrow straight down and pupate at the end of the burrow without forming any inclined cell. In one instance the worm simply remained in the ear upon which it had been feeding, formed a cell, and pupated.

During the summer months, at moderate temperatures, it seems to make little difference in the length of the pupal state whether the pupæ are on the surface, kept perfectly dry, or continuously moistened. Nos. 4, 10, 13, and 14 in Table XII were placed in perfectly dry earth to pupate, and kept dry up to date of hatching. The time was 9, 11, 11, and 9 days, respectively, or an average of 10 days. Nos. 2, 3, 5, 8, 9, and 11 of Table XII were placed in moist earth and moistened each day during the pupal state. Time was 9, 9, 10, 11, 9, and 10 days, respectively, an average of 9.6 days. No. 12 was placed upon a corn plant in a 6-inch flower pot, half full of moss, kept saturated with water so that when lifted it would drip. This was not intended for the worm to pupate in, but simply to keep fresh the plant upon which it was feeding. Unawares the worm went down into the wet moss to a depth of 2 inches, formed a cell, and pupated. The pupa was left in this cell, and the moss kept constantly wet to excess. Nine days afterward the moth issued. During the entire time the cell had not been broken into, and the pupa may not have been subjected directly to the excessive moisture. These facts are given for what they are worth, as bearing upon the claims made by some that either excessive rain or drought retards the development of the insect. Those kept perfectly dry were exposed to an average daily temperature of at least 95° F. Those kept constantly moist had about the same temperature. The results showed that practically no difference in the length of the pupal state existed. This, it must be remembered, applies only to the spring and summer months with high temperature. During the fall and winter, when decided changes in both moisture and temperature take place, simultaneously, their development is certainly retarded.

IMAGO.

The moth varies in color from a distinct olivaceous to a brownish hue. Some claim that a relation exists between these types of color in the imago and the colors of the larvæ. The records presented in Table XII bear directly upon this point. Nos. 4, 5, 6, 7, 9, 10, and 14, were green larvæ, and the color of the moths was dark, dark, dark, olivaceous, dark, dark, and olivaceous, respectively. Thus both types of color in the moth occur for the same color of the larvæ. It must be noted, however, that some of the pupæ named were kept perfectly dry, others wet or moistened continuously. On this point for those kept dry may be quoted No. 4, which is dark, and No. 14, which is olivaceous. For those kept moist, No. 3 is olivaceous and No. 5 is dark, both of which, also,

had pupated beneath the surface. This record, from the nature of the case, is entirely too limited to generalize from, further than to note that if any relation exists between the larval color and that of the moth there are exceptions. These exceptions prevail, also, for the conditions of dryness, moisture, and surface pupation in relation to the same question.

The numerous plants upon which the female deposits, together with her reckless habit of miscellaneous deposition, compels the wandering about of many of the recently-hatched larvæ which find themselves in unfavorable circumstances and perish in their search for more suitable conditions. The loss occasioned by this misdirected deposition accounts in part, as has already been noted, under the head of "Other Food-plants" for the small number of worms as compared with the number of eggs which a single female is capable of depositing.

When the females come out from their hiding places they confine themselves almost entirely to their host plants, either for feeding or for deposition. From the time of hatching to the end of the egg-laying period they are bent upon business whenever they appear, and their attention is not easily distracted. This fact becomes of great importance in the use of lights and poisoned sweets, and will be considered more fully subsequently.

The food habits of the moth are not injurious at any time or in any manner. Some planters assert that in depositing their eggs they puncture the squares and forms, causing them to drop. The fact is that the ovipositor of the female is not strong enough to perform such an act, and, furthermore, the eggs are laid on the surface.

NUMBER OF BROODS AND HIBERNATION.

At Shreveport the first brood of larvæ resulting from imagos which hatched from hibernating pupæ matures about June 1. The second brood begins to appear about the 10th of June. The larval state of the first brood is about fifteen days, and the pupal state about ten days. For the third and fifth broods the time is more variable and the pupal state may run from fifteen days to over a month, or the entire winter. The majority of the fifth brood of pupæ pass the winter as such, though a few issue before the season closes and hibernate as moths. These hibernating moths appear and begin depositing much earlier than, and make a troublesome confusion of broods with, those resulting from hibernating pupæ. This, together with the fact that Boll Worms—many quite young—can be found at Shreveport, La., as late as November 20 justifies the statement that for that locality, beginning in the spring with the few hibernating moths, we have a series of small broods along with the regular ones, the former producing a sixth brood which hibernates in the pupal state, the latter only five broods of which a few of the last hatch and hibernate as imagos. This mixing of broods explains why full-grown larvæ and newly-hatched ones are found simul-

taneously at any time after the middle of May. The winter of 1890–'91 was unusually mild in Lousiana, and the spring proportionately earlier. Hence the above dates may not be average or normal, and, in any case, are intended to have only a local application.

The foregoing discussion is based upon observations made in northern Louisiana and Mississippi. In northern Mississippi the evidences of a portion of the last brood hibernating as imagos are more meager and less conclusive. In Arkansas the reports of observers and the time of greatest depredation seem to point conclusively to the fact that all of the last brood hibernate in the pupal state, while from the fact that the spring is later than further south, their habits of hibernation are more constant, the first brood issuing more evenly and all the broods being better defined. The fall season is also more severe, if not earlier, and hence only the five broods occur in the cotton-producing portion of the State. In the remainder perhaps only four full broods occur, with an incomplete fifth one. On the contrary, in southern Texas the winters are mild and the spring comes much earlier than in the cotton region of Louisiana or northern Texas. From constant communication with cotton-planters and other observers in southern Texas, it was determined that there could be no doubt about the hibernation of a considerable portion of the last brood as imagos. These appeared and began depositing earlier than at Shreveport, certainly producing six distinct broods and a partial seventh by the close of the season. Those issuing from pupæ in spring produced six well-defined broods.

Failure to take into consideration these geographical and meteorological differences over so vast a territory as the culture of cotton occupies has resulted in great confusion and much controversy among cotton-planters as to the number of broods and the times of their appearance. The truth probably is that each is correct for his own district. The determination of the time of appearance of the several broods of moths and when their egg-laying is most abundant is a matter of great importance in intelligently managing the trap-crop method for protecting the cotton, and will be further discussed hereinafter.

PARASITES.

On June 15 specimens of *Pteromalus puparum* obtained from *Pieris rapæ* in great numbers, were placed with a large Boll Worm upon earth in a wide-mouthed bottle. As both males and females of the parasites had been placed in the bottle, some were seen copulating later. The parasites frequently alighted on the back of the larva. The worm, opening its jaws, would quickly and violently throw its head and the anterior part of its body around to the point where the insect sat, and often captured it. This was not merely accidental, for the process was often repeated and a micro was nearly always captured. Once in the jaws of the larva, the parasite was quickly eaten. Before pupation, June 19, the larva had in this manner eaten about thirty of the forty or fifty parasitic in-

sects with which it had been confined. June 29 the pupa hatched. The parasitic adults therefore had failed to deposit any eggs upon the larva, or, if so, the eggs had failed to hatch.

EGG PARASITES.

On June 3 *Trichogramma pretiosa* Riley was found quite plentiful in some localities. Parasitized Heliothis eggs were placed in a vial for the purpose of rearing the imagos. On June 4 some had issued, and a female was observed in the act of depositing her eggs. She first made a careful examination of each part of the egg. Selecting a certain point, she took a firm hold on the egg with her legs, elevated the head and thorax, bringing the entire weight of the body to bear on the end of the ovipositor. Then, by a series of drilling motions, the shell was punctured and the egg deposited. During the entire process the antennæ were kept perfectly quiet and folded down upon and over the vertex. The act of deposition occurred three times in ten minutes.

On July 6 plenty of Heliothis eggs were again found on the silks of trap corn, and many of them were parasitized. Concentrating the deposition of the Boll Worm eggs upon the trap corn greatly increases the opportunities of the parasites for depositing in them, and the benefit derived from it in this way is very great.

A second parasite was reared from Boll Worm eggs. It is somewhat larger and much darker than *Trichogramma pretiosa*, but does not occur in nearly so great numbers. The specimen was referred to Dr. Riley for examination. He found it to be an unnamed species of the genus Telenomus.

PARASITES OF THE LARVA.

Euplectrus comstockii and *Chalcis ovata*, whose life-histories and peculiar habits have already been noted in the Fourth Report of the United States Entomological Commission, have been reared from the Boll Worm. The specimen from which *Chalcis ovata* was reared also contained many larvæ of *Phora aletiæ*. From these numerous specimens of *Hexaplasta zigzag* were reared. It seems strange, however, that only a single specimen of *C. ovata* and two or three of *P. aletiæ* should be obtained from the worm. The explanation, if any, must be that *H. zigzag* parasitized the larvæ of both.*

Another beautiful parasite is a species of Limneria, which was mostly found in the early part of the season, one from a Boll Worm taken from corn and another from a tomato vine; the former in May, the latter in June. The parasitic larva issues from its host and spins a peculiarly marked white cocoon with brownish or reddish spots arranged in regular order.

* The supposition that the Hexaplasta could have parasitized the Chalcis larva is undoubtedly unfounded.—C. V. R.

A large Dipterous parasite was often reared from Boll Worms. They most frequently attack them later in the season, as only at that time were they obtained.

OTHER NATURAL ENEMIES.

Boll Worms were scarce in cotton at Shreveport, and the studies which had been planned for determining the relation of birds to this insect could not be made. Accordingly only a few statements from correspondents will be given on the subject. Prof. H. A. Morgan, of Baton Rouge, La., in a letter of June 6, states that "sparrows have been noticed to feed upon them occasionally." Later a letter was received from Mr. S. B. Mullen, Harrisville, Miss., in which he stated that sapsuckers alighted upon the ears of trap corn and ate about half of the Boll Worms found in them. Mr. Mullen was then requested to shoot a number of the birds, extract their crops and stomachs, and forward them for study. He experienced some difficulty about mailing alcoholic material, and hence made the examinations himself. He reported that numerous heads of Boll Worms were found in the stomachs and some small Boll Worms in the crops.

Since then, through the kindness of Mr. W. B. Barrows, of the Division of Ornithology and Mammalogy, it has been determined that the species in question is really not a true sapsucker, but probably the Hairy or Downy Woodpecker, both being known to be insectivorous.

ANTS.

In spring and early summer larvæ in general are not so abundant, or at least the Boll Worm in young corn in rather isolated fields is more accessible than many other larvæ. It is during this period that the attack by ants is most frequently noted. About June the larvæ of other species become numerous, plant-lice are met with everywhere, and the attack by ants becomes so divided that it not only appears to be of less economic importance, but requires constant close watch to witness an ant-boll-worm tragedy. Failure to consider the season doubtless accounts for the difference of opinion expressed by planters and other observers.

Before corn begins to silk and put forth ears, and to a certain extent during and after that time, ants freely attack any larvæ they may find crawling about on the ground or upon corn plants.

There are two species which are specially antagonistic in temperament, and these are the ones upon which most of the observations are made. One is *Solenopsis geminata* Fabr. and the other *Dorymyrmex pyramicus* Roger. For example, June 1 a full-grown Boll Worm on a corn plant was teased until it dropped to the ground. In a moment a small ant (*Dorymyrmex pyramicus*) pounced upon its back and could not be dislodged by the most violent and promiscuous rolling and jerk-

ing of the larva. After a short interval three other ants arrived and joined in the attack. After about five minutes the larva had been exhausted by its violent tumbling, and was perfectly helpless when dragged away. A second larva, more than half grown, was later dropped on the ground near by. It began to travel, but soon crossed the path of another species of ant (*Solenopsis geminata*). At once one pounced upon it, when the larva began rolling in the dust and loose earth, but failed to dislodge its enemy. After a few minutes, other ants came to the assistance of the first until about half a dozen were engaged in the work of biting and tormenting. The larva was soon exhausted and completely at the mercy of its enemies.

In August and September such attacks are rarely witnessed, and larvæ can even be thrown in the path of these ants without danger of attack in every instance. When not hungry, or soon after they have had a fight with a Boll Worm, observation reveals the ants touching the larvæ or even running over them without making an attack.

June 10, on ears of corn, the ants were seen attacking Syrphid larvæ, probably *Mesograpta polita*. They simply picked the larvæ up in their jaws and carried them down the plants to their burrows. July 1, ants were observed feeding upon Syrphid pupæ of probably the same species as above noted.

June 1, ants (*Solenopsis geminata*) were seen at a hole in the husks of an ear of corn. The husks were carefully removed without disturbing the ants. They were found feeding upon the liquids of a recently killed half-grown Boll Worm. The ear being well stocked with larvæ, the injured one had doubtless been killed by another of its own species, and while devouring it the victor was probably disturbed by the ants and abandoned its morsel for the benefit of the intruders. Subsequent persistent observation verified this surmise and showed that the ants seldom directly attack and kill a Boll Worm in the ear. It has already been explained that the Boll Worm has a natural tendency, when crowded or provoked, to feed upon its own species. The ant has learned to know that infested ears of corn are an excellent source of supply for juices and they are found most plentifully in those ears. After entering, the best portions are selected, the little surveying which this requires bringing them into contact with the Boll Worm. This living thing seems to excite them and they begin to bite and tease it until it becomes enraged and attempts to get away. In doing so the larva bites to the right and left and kills many of the smaller larvæ which it happens to meet. The ants are very fond of the blood which oozes from the wounds of the injured larvæ, and at once proceed to feast upon it. Should the injured worm in its weakened condition attempt to get away the ants soon overpower it. The first worm, however, having once had a taste of blood, continues its depredations upon the slightest provocation, and, as would seem from breeding-cage observations, is, for a short time and if opportunity offers, often inclined to

feed in this way rather than in the usual one. Whether the ants do their teasing in the hope of inducing boll-worm fights, or only to drive out the larvæ so as to have full possession of the ear, the fact remains that in either case their actions are often responsible for the cannibalism which occurs among the Boll Worms in the ears. The ants seem to prefer the fresh juices of grains of corn yet in the milk to those found in the excrement of Boll Worms or the decaying grains which have previously been eaten into. In order to enjoy the freshest juices, however, they must first drive the Boll Worms from the point. It would seem, therefore, that the cannibalism in ears of corn due to the behavior of the ants is probably more incidental than intentional. The importance of their actions, however, is not to be underestimated. Their teasing process does not need to be repeated for each Boll Worm found in an ear. When a large Boll Worm is once thoroughly provoked in this manner it often goes to every part of the ear, and wherever another larva is found a fight ending in a dead Boll Worm is quite certain to follow. This may continue until only one remains, or it may go only to the extent of killing a few at that time. The slightest provocation within a reasonable time thereafter seems to be sufficient to start the exterminating process again. One such provocation by ants, therefore, often suffices to clear an ear of all Boll Worms but one. It should be borne in mind, however, that crowded conditions where the larvæ encroach upon each other furnish the same provocation for fighting. Cannibalism among Boll Worms, therefore, is not the result of a single agency, but of several, which directly or indirectly contribute to bring about the result.

WASPS.

The large red wasp, *Polistes rubiginosus*, so common in cotton fields, carries off the larvæ of many species found feeding upon cotton, and doubtless takes a Boll Worm occasionally when they are present. *Polistes bellicosa*, *P. perplexus*, *P. gluerosa*, *P. annularis*, *Pompilus atra*, *P. americana*, *P. philadelphicus*, *Priocnemis fulvicornis*, and *Chalybion cæruleum*, are all common in cotton fields, and doubtless capture Boll Worms, as well as other larvæ.

OTHER INSECTS.

Other insects which are known to be carnivorous are often found abundant on corn silks and infested plants. Notable examples on corn silks are *Scymnus collaris* and *S. cervicalis*. These two species probably puncture or eat into the Heliothis eggs found upon the silks.

Two species of Robber Flies (*Erax lateralis* and *Deromyia* sp.), were observed catching Boll Worm moths on the wing.

Metapodius femoratus is frequently found preying upon the Boll Worm. The young seem to be especially beneficial in this respect. Unfortunately the eggs of this species are attacked by an egg parasite which

breeds in them in great numbers. This is an undescribed species of the Chalcidid genus Encyrtus.

Geocoris punctipes attacks the small Boll Worms and the Spiny Soldier-bug, *Podisus spinosus*, has often been observed at its beneficial work.

August 24, at Dallas, Tex., upon tobacco plants well stocked with eggs of the Boll Worm were found great numbers of the young and adults of a species of Dicyphus. By counting a number of eggs which were shriveled and evidently dead, it was determined that about 5 per cent were in this condition. The Dicyphus was the only insect found plentiful upon the plants, and it seemed reasonable to conclude that to it was due the puncturing of the eggs. After long and patient watching it was finally found that they really did the work.

Triphleps insidiosus punctures the eggs of Heliothis and sucks their contents. The egg-shells appear slightly shrunken and shriveled afterwards. From continuous observation one is forced to realize that no small per cent of the eggs is destroyed in this way. The empty egg-shells are met with in almost every observation. Mr. Banks, who made most of the observations upon this insect, estimates that probably 10 per cent of the eggs are destroyed in this way. From my own studies I am convinced that the estimate is none too large. This insect preys also upon its own species, at least in confinement. Four specimens, collected from cotton, were placed in a vial for subsequent study, and several hours later one was found with another impaled upon its beak.

These small insects are commonly found behind the involucres of squares and bolls and are very abundant in corn silks. Here the Heliothis eggs are most numerous and afford the Triphleps a good opportunity to feed upon them. The young and pupæ are small, wingless, pale or often bright red, and could readily be mistaken for the young of the Chinch Bug in general appearance, though they are shorter and more triangular in shape.

No spiders were ever observed in the act of devouring a Boll Worm, but several species, very common upon cotton plants, have been so constantly observed destroying other insects found there that probably the reason why no Boll Worms were taken is because they were scarce. The following observations upon some of the more carnivorous species may be recorded: *Phidippus tripunctatus*, devouring a Syrphid (*Mesograpta polita*) upon corn September 25; same species upon cotton bolls October 11 and 13. *Chriracanthium inclusum* on young bolls. *Anyphæna gracilis* from corn silks. *Dendryphantes nubilus* and *D. octavus* from cotton bolls, the former devouring a plant-louse. *Peucetia viridans* and *Runcinia aleatoria* on bolls, the former devouring a large Dipter.

INSECT RAVAGES MISTAKEN FOR THOSE OF THE BOLL WORM.

Thecla pœas.—The larva of this insect bores cotton bolls just as does the Boll Worm. Occasionally it eats a hole into the young portion of

the thick main stem or at the juncture of the peduncle with the stem. The larvæ when young are almost entirely whitish, but as they become more mature they turn to a livid green. Every larva collected during the season was parasitized and failed to mature. In one instance a small Hymenopter was bred. In another a Tachinid was reared. The parasitic larva issues from the body of its host near the head. A nearly grown Thecla larva was found at Shreveport as early as July 1, another at Curtis July 3, and a very young specimen at Briar Field July 25. The distance between Curtis and Briar Field is about 40 miles, showing that the species is well distributed and that the observations on cotton were not exceptional cases. Mr. Mullen, of Harrisville, Miss., also reports this species feeding upon beans and corn in his locality.

Prodenia lineatella.—In confinement the larva feeds almost exclusively upon the young bolls and squares, showing that these insects have the genuine Boll Worm habit. The very young larvæ are quite light-colored, and in May and June are often found in the buds of young corn plants, feeding as does the Boll Worm. The mature worms have a distinct velvety black appearance, with a narrow yellow line dorsally and a whitish triangular patch on the front of the head. In September this species was received from Mr. C. F. Yarbrough, Camden, Ark., as feeding in broom corn.

Platynota rostrana.—The head of the larva is reddish or black and a similarly colored calloused patch dorsad of the first segment. Body pale greenish, slightly hairy. In the fields upon cotton plants or when placed in breeding cages, they freely attack and bore into young bolls, feeding upon their contents. July 8, one pupated between a fold of the involucre which had been carefully fastened together by silk threads. July 13, a second larva pupated. July 15, the first pupa hatched, the second on July 19, the pupal state therefore being seven and six days, respectively.

During April, May, and June several species of larvæ ravage in the buds of young corn, exactly as does the Boll Worm, and many are not easily distinguishable from the darker Boll Worms.

Agrotis ypsilon.—The larvæ of this species were collected from corn April 20. These larvæ are at times cannibalistic. In breeding cages a large specimen was observed devouring a younger one of its own species.

Laphygma frugiperda is abundant upon trap corn in June and July, and many planters had mistaken them for Boll Worms. One specimen of this species was taken from corn July 10 and July 29.

Baris ærea Boh., was found November 21, eating a small hole into the peduncle of a young boll. The small, round hole could not be distinguished from the injury occasionally done by the young Boll Worms.

Parajulus impressus Say is occasionally found between the involucres and young bolls during September and October. They sometimes feed at the base of the boll, causing it to drop, and leaving a black spot much the same as when a Boll Worm starts to enter, but deserts it without further injury.

Calocoris rapidus.—This Capsid is very common upon cotton plants, and is usually found between the involucres and bolls. Its damage is done by puncturing the bolls with its beak. This leaves a small, round black dot at the point of the puncture, and this is the mark so often attributed to the moth of the Boll Worm. The injury nearly always has the effect of causing the boll to "flare" and drop, or if not, then the tuft of cotton in that section of the boll becomes stained. *Largus cinctus* proceeds in the same manner as *Calocoris rapidus*, leaving the characteristic puncture upon the fruit.

Homalodisca coagulata.—This leaf-hopper can be found quite common upon cotton plants from the 1st of June. Earlier it is found most abundant upon the young growth of poplars along the bayous about bottom-land cotton fields. Though common upon cotton it seems to prefer to feed and breed upon the new growth of the trees just mentioned so long as it remains fresh and growing. Nevertheless, it does considerable damage to cotton both by its habits of feeding and those of egg deposition. The female possesses two cutting serrated or saw-like blades, which fit together and form the ovipositor. With this she makes punctures for the reception of the eggs. To do this she leaves the central stem where the adults are usually found and locates among the tender growing portions, especially young "forms" or "squares." The act of deposition was twice observed on the involucre or "ruffle" of these portions. The female braced herself upon all legs, the head and anterior portion of the body elevated. The very thin pointed ovipositor was then exserted, and by a forcible sawing-like operation was gradually inserted underneath the epidermis. The channel was made concave, the distal end almost coming to the surface again. The long, slightly curved, cylindrical white egg was then introduced and the ovipositor withdrawn. The time occupied by this process was about one or two minutes. After a short interval a second egg was laid in like manner alongside of the first but slightly in advance of it. A few hours after deposition, slight, pale, blister-like swellings were noted over the points where the eggs were found. One egg was dissected from the leaf and saved as a reference specimen. Unfortunately a larva of *Thecla pœas* was temporarily placed in the same bottle as the form in which the remaining egg was found. When next observed the Thecla had eaten a hole directly through the portion in which the egg had been deposited, and the latter was therefore destroyed. As a result, the duration of the egg state could not be determined. The eating of the egg by Thecla was doubtless only a coincidence. The recently hatched larva is entirely whitish, and keeps hidden among the very young leaves or the involucres of "forms" and small bolls. The very young carry the abdomen elevated almost at right angles with the body. They feed by puncturing the epidermis at the base of the flower bud, or the very young boll, or quite frequently proceed to the short, tender peduncles. Soon after this injury is done the form or small boll will "flare," turn pale, and drop off. If examined when

about to drop off, a small roundish black spot will be found upon the peduncle, the base of the form, or boll. These markings the planters designate as "sharpshooter" work, many attributing it to the Boll Worm, others to the young Boll Worm, and occasionally an observing planter is found who truthfully assigns the injury to some insect other than the Boll Worm. The other extreme of intelligence is also found which stoutly maintains that this small leaf-hopper is the real Boll Worm "fly."

The young become gradually darker with each molt. When half grown they are quite bluish or lead-colored, with distinct wing-pads. At this age they begin to run about the plant more, and as they become still more mature are often found on the central stem. Previous to that time they confine themselves quite closely to the tender, growing parts of the lateral branches. When disturbed they at once rush down to the central stem, run up at first, then if still pursued, down again, dodging from side to side until they feel that they have escaped, when they stop and rest, head downward.

The imago is brownish, sometimes tinged bluish, or in older specimens faintly reddish. Fresh females often have a white powdery spot on the middle of the fore wings. This spot rubs off easily and is not apparent after a time. The adults make a distinct buzz in their short flight from plant to plant. They feed usually upon some part of the central stem. When feeding they rest head downward and puncture the bark with their beaks. While feeding or resting in this position they incline the tip of the abdomen outward, often throwing off some half dozen drops of liquid in quick succession. The squirting of these drops is not noted in the very young, and only occasionally in specimens not yet full grown. It seems rather to be a habit of the adult. The imagos dodge to the opposite side of the stem when approached from one side and continue to do so just as the young. Though found feeding mostly on the central stem of the cotton plant, the females leave these parts and locate among the younger portions when they deposit their eggs. July 15 Mr. Banks dissected a female and found nineteen eggs, including those that were being formed. The female is not easily disturbed when depositing, and can even be pushed aside without inducing her to jump or fly. In one instance the form having the depositing female upon it was plucked and held in the hand, where her performances were quietly observed under cover of the hand lens.

Late in the season—that is, from about the 1st of September—the habits and actions of the adults become variable and less characteristic. There are certainly two, possibly three, broods during the season. The adults begin making their appearance in numbers from about June 1. By the middle and latter part of June numerous young can be found. The second brood begins depositing about the latter part of July. After the first days in August the adults are not so abundant until the young begin maturing again. The male adults are easily at-

tracted to lights, while the female is rarely caught in this way. Of twenty-two specimens trapped twenty were males and two females. At a lamp experiment July 19 nine specimens were captured, all males: Mr. Banks often collected adults at random, and without regard to sex, from cotton plants during the day. Eight specimens were taken on one trip, four males and four females. July 15 fifteen were captured, fourteen being females and one male. A third capture was found to contain six females and two females. This shows that females were plentiful in cotton fields at the time the lamp experiment had been made, but were not attracted. The damage to cotton by this species is due in great measure to the immature forms of the insect.

It appears that during July and August cotton fields surrounded by poplar growths along the bayous suffer the greatest attack. This is to be expected, since during June the insect lives mostly upon these trees, the young growth of which becomes too hard and tough later in the season. As has been stated, it is most numerous along river bottoms and bayous. Away from these regions this species is not at all common in cotton fields. In the upland regions of Texas, where continuous observations for one week in August were made, not a single specimen was found upon cotton. Mr. Banks, who took an extensive trip through central and southwestern Texas during July, reports the rare occurrence of this insect in those regions. Young poplar is probably their choice for food and egg deposition, but they are often found upon various kinds of weeds and miscellaneous plants. This being the case, the question of a remedy becomes a difficult one. The only recourse which seems at all practical is to control the number of young poplar trees along the bayous, keeping them at a minimum so as to obtain the maximum number of insects upon them. Then about the middle or latter part of June give them a thorough application of a strong solution of kerosene emulsion. This would kill many of the adults and most of the young, which are abundant upon them at this time.

Another nearly related species, *Proconia undata*, mostly found upon willow, is occasionally noted upon cotton. Whether its injury is similar to that of the Homalodisca has not been positively determined, but the facts already noted for the latter indicate that it may be.

REMEDIES FOR THE BOLL WORM.

LIGHTS FOR ATTRACTING THE MOTH.

The experiments presented in Bulletin 24 (pp. 33–38) proved conclusively that the ordinary lamps used by farmers and the methods of using them were inefficient. Until proven otherwise, the reasons assigned for such results were that the lights were not brilliant enough, together with being unprovided with extending wings as a background against which insects flying near by might strike and be trapped. A lamp was devised to meet all these requirements so that it could be ef-

ficient if the nature of the case permitted. The following is a description of the lamp: A tin can, 6 inches in diameter, holding about a half gallon of oil, was provided with a No. 2 wick burner capable of receiving and holding a large chimney. Around the tin can was fitted a movable tin band to which had been soldered four stout upright wires. To these wires were fastened sheets of tin a foot square, extending at right angles and from the top of the can. These wings, together with the 6-inch space between for the lamp, furnished a surface of 2½ feet toward any direction against which insects flying near might strike and drop into the large pan in which the lamp was placed. The lamp is not easily blown out of the pan if the precaution is taken to have the wings extend out far enough to catch the rim of the pan. Though a chimney was always used, in no instance was the light blown out when a strong breeze was prevailing. By experiment this lamp was found to emit a brilliant light, which was not hindered in its transmission by the extended wings.

Experiments were begun as early as May 13, 1891, and repeated at intervals on through the season. The results were all so uniform that only a few experiments need be reported in detail.

Experiment 2.

May 15.—Lighted at 8:30 p. m. Sweet corn in a garden. Locality, upland in edge of timber. During the afternoon of that day many recently deposited Heliothis eggs were found on the corn silks.

8:40.—Boll-worm moth flying along a row of corn next to the one in which the lamp is placed. When opposite the lamp, only 3 feet distant, it flew at right angles away from it. Lamp was on a level with the ears of corn on the plants and could be seen over the entire patch.

9:00.—Another moth flying as before came near, but flew away without showing any attraction to the light.

9:06.—One passed the lamp, turned, came near again, alighted upon the edge of the pan and sat there. In attempting to fly away it struck one of the tin wings and dropped into the pan.

No more moths being observed, the experiment was closed at 9:40. Though the moths were not abundant several females were seen depositing upon the fresh corn silks.

To convey a general idea of the nature of the various trappings aside from the primary insect desired, experiments 3, 4, and 5 have been collated and are presented in Table XIII.

TABLE XIII.—*Number and kind of insects caught.*

LEPIDOPTERA.

Experiment.	Date.	Noctuidæ.		Geometridæ.		Pyralidæ.		Tortricidæ.		Tineidæ.		Total specimens.
		Species.	Specimens.	Species.	Specimens.	Species.	Specimens.	Species.	Specimens.	Species.	Specimens.	
3	June 9	......	......	1	5	3 Botis ..	12 15	1	5	2 Plutella.	9 7	....
	Total	......	......	1	5	4	27	1	5	3	16	53
4	June 12......	......	......	......	......	2	7	1	4	3 Plutella.	10 15	....
	Total	......	......	......	......	2	7	1	4	4	25	36
5	June 27......	2	5	3	6	3 Botis..	3 30	1 4	4 4	5	15	......
	Total	2	5	3	6	4	33	5	8	5	15	67

COLEOPTERA.

Experiment.	Date.	Carabidæ.	Staphylinidæ.	Scarabæidæ.	Elateridæ.	Curculionidæ.	Scolytidæ.	Cerambycidæ.	Chrysomelidæ.	Coccinellidæ.	Total.
3	June 9......	30	......	Lachnosterna..15 Cyclocephala ..35	1	......	......	......	7	....	88
4	June 12...	Large 8 Small 70	1,000	Pelidnota.......1 Lachnosterna..30 Cyclocephala 40	25	10	.....	4	6	....	1,194
5	June 27...	Large 12 Small 150	800	Lachnosterna ..55 Cyclocephala ..75	50	7	5	7	9	Megilla 2	1,172

HETEROPTERA.

Experiment.	Date.	Cydnidæ.	Pentatomidæ.	Lygæidæ.	Capsidæ.	Acanthiidæ.	Corisidæ.	Total.
3	June 9....	......	2	....	......	....	Corisa 60	62
4	June 12...	......	......	Melanocoryphus...18	6	Triphleps ..4	Corisa 15	43
5	June 27...	30	....	Melanocoryphus..100 Myodocha 3	......	....	Corisa ..1,000	1,133

HOMOPTERA.

Experiment.	Date.	Jassidæ.	Fulgoridæ.	Membracidæ.	Totals.
3	June 9	Aulacises......20	Ormenis ...11	....	37
4	June 12	35	17	13	65
5	June 27	Aulacises ......15 Deltocephalus..20	Ormenis ...10	....	45

TABLE XIII. —*Number and kind of insects caught*—Continued.

DIPTERA.

Experiment.	Date.	Mosquitoes.	Tipulidæ.	Mycetophilidæ.	Totals.
3	June 9	1,000	15	11	1,026
4	June 12	30	12	13	55
5	June 27	200	....	100	300

NEUROPTERA.

Experiment.	Date.	Caddice flies.	Chrysopa.	May flies.	Totals.
3	June 9	20	....	10	30
4	June 12	5	....	6	11
5	June 27	7	1	....	8

ORTHOPTERA.

Experiment.	Date.	Œcanthus.	Nemobius.	Platamodes.	Totals.
3	June 9	3	....	....	3
4	June 12	....	....	4	4
5	June 27	1	4	....	5

Very few parasitic or beneficial Hymenoptera were trapped at any time and hence this order is omitted.

Table XIII can best be reviewed by taking up the orders *seriatim.*

Lepidoptera (*Moths*).—The only species of any considerable economic importance in the South is the Cabbage Plutella (*Plutella cruciferarum*). Experiments 3 and 4 were both located near a gardener's cabbage field. Its significance in this connection lies in the suggestion that gardeners growing cabbages extensively and troubled with this pest might resort to lamp trapping with advantage.

Coleoptera (*Beetles*).—Some of the large and well-known predaceous beetles were captured together with hundreds of many of the smaller species. Of the beneficial ladybird family a few specimens were trapped at various intervals. But this loss of beneficial insects is in part counterbalanced by the capture of several injurious species none of which, however, except the white grub beetles, *Lachnosterna longitarsus* and *Cyclocephala immaculata* were caught in great numbers. The last two species and a species of the wireworm beetles *Monocrepidius vespertinus* were caught by hundreds and may be considered a profitable catch. Several species of injurious weevils and flea-beetles were commonly trapped though not in great numbers. Following is a selected list of some of the beneficial and injurious beetles which were quite constantly trapped during the progress of the experiments. None of these were captured in great numbers. For the determinations of the species I am indebted to Mr. E. A. Schwarz of this Division.

BENEFICIAL.

Predaceous beetles:
- *Loxandrus agilis.*
- *Badister micans.*
- *Chlœnius laticollis.*
- *Chlœnius pennsylvanicus.*
- *Cratacanthus dubius.*
- *Stenolophus dissimilis.*
- *Bradycellus nigriceps.*
- *Megilla maculata.*
- *Hippodamia convergens.*
- *Coccinella 9-punctata.*
- *Coccinella oculata.*
- *Mysia pullata.*
- *Exochomus marginipennis.*
- *Scymnus cervicalis.*

INJURIOUS.

Flea-beetles:
- *Systena elongata.*
- *Epitrix fuscula.*
- *Chætocnema pulicaria.*
- *Haltica ignita.*
- *Phyllotreta bipustulata.*

Wire-worm beetles:
- *Glyphonyx inquinatus.*
- *Monocrepidius vespertinus.*
- *Monocrepidius lividus.*

Miscellaneous:
- *Lachnosterna longitarsus.*
- *Cyclocephala immaculata.*
- *Calandra oryzæ.*
- *Typophorus canellus.*
- *Lina scripta.*
- *Diabrotica 12-punctata.*
- *Balaninus caryæ.*
- *Myochrous denticollis.*
- *Colaspis flavida.*

Heteroptera (*True Bugs*).—Only one species of known beneficial importance is noted. It is the small *Triphleps insidiosus* which punctures boll-worm eggs. In other experiments not tabulated an occasional soldier-bug was caught usually *Podisus spinosus.* In some of the experiments an insect (*Calacoris rapidus*) which contributes much to what is popularly termed "sharpshooter" damage was trapped in small numbers. A probably injurious cotton insect which the planters often mistook for the genuine Cotton Stainer (*Dysdercus suturellus*) is *Melanocoryphus bicrucis.* This insect was trapped by hundreds but subsequent study proved that fully 90 per cent were males.

Homoptera (*Leaf-hoppers, etc.*).—*Homalodisca coagulata* was caught in great abundance. Subsequent study showed that about 90 per cent were males.

In the three orders, Diptera, Neuroptera, and Orthoptera, nothing worthy of consideration was captured except a few specimens of the beneficial lace-wing flies.

Experiment 6.

Arlington, Tex., August 27.—Lighted at 7 p. m. and placed between rows of cowpeas adjoining a cotton field. The rows of cowpeas were 6 to 8 feet apart and had many Boll Worm moths flying about them feeding. The weather was warm and pleasant, the night very dark. Being placed between the rows, a distance of only about 4 feet remained from which to attract the passing moths. For an hour the moths kept flying up and down the rows on either side of the lamp, fed freely, deposited eggs, and paid no attention whatever to the light. A volunteer pea vine was near the center of the row having a few branches extending well up projecting over the edge of the pan within 10 inches of the flaring light. Some fresh blossoms upon them proved attractive, and a few adventurous females visited them, sipped of

their sweets for a time by lamplight and then flew away to continue their usual vocation. This act of defiance sent consternation to the hearts of some 15 or 20 planters who had been invited to attend the experiment and who during the day had insisted that if properly conducted, lights were effective agencies. All admitted that the test had been made under the most auspicious circumstances and yielded their former position with commendable grace and sincerity. Their attention was further called to a number of parasitic Hymenoptera which had been caught, some beneficial and predaceous beetles, soldier bugs, lace-wing flies, and many other species of little known economic importance such as have heretofore been given in detail and need not be repeated.

To summarize briefly, it must be concluded that the use of lights for attracting and trapping the Boll Worm moth is entirely useless. The character and habits of the other insects caught, as shown by Table XIII and its discussion, are found to be pretty evenly divided between those which are beneficial and those considered injurious. Most of the insects noted as injurious are not of special economic importance throughout the cotton region, and hence their consideration in this connection may be justly omitted. The use of lights, so far as the cotton planter is concerned, results only in the destruction of beneficial insects and is, therefore, an absolute disadvantage. Such being the case money expended in this practice is an entire loss. As a protective agency lights are a failure and should be unhesitatingly discouraged and condemned.

POISONED SWEETS.

Much has been claimed for this method of destroying the moths and a number of experiments were made to test the value and importance of the remedy. The various mixtures were applied with a Woodason liquid sprayer upon rows of cowpeas which had made a rank growth and were blooming profusely. They were freely visited by Heliothis from about 4 p. m. until 8 or 9 at night. All conditions for the experiments were favorable and furnished a good test of the poisons. The experiments were made upon Mr. C. F. Mercer's farm at Arlington, Tex., where Dr. L. O. Page, of that city, also rendered valuable assistance. By direction Dr. Page prepared saturated aqueous solutions of the poisons, and mixtures of desirable strengths with vinegar or beer were made subsequently.

Experiment 1.

August 27 (*4:15*).—Beer, 8 ounces; saturated cold-water solution of arsenic, 4 ounces.

August 28 (*3 p. m.*).—Leaves, blossoms, or young pods slightly or uncertainly injured.

Experiment 2.

August 27 (*4:25*).—Beer, 4 ounces, with 4 ounces of the same poison solution used in experiment 1.

August 28 (*p. m.*).—Foliage, blossoms, and very young pods badly scorched.

Experiment 3.

August 27 (4:35).—Vinegar, 4 ounces; 3 ounces saturated arsenic solution.

August 28 (p.m.).—Foliage, blossoms, and an occasional young pod badly scorched.

August 27.—Dr. Page was directed to prepare the following solutions:

(1) Saturated cold-water solution of commercial arsenic.

(2) 1 ounce corrosive sublimate to 1 pint cold water.

(3) 1 ounce potassium cyanide to 1 pint cold water.

Samples of each solution were kept, taken to Shreveport, and tested. They had been perfectly prepared, and the poisons were therefore actually in solution at the time of application.

The following two mixtures were prepared and used to dilute the poisoned solutions in experiments 4 to 6, inclusive:

(1) 3 pints beer to 1 pint molasses.

(2) 3 pints vinegar to 1 pint molasses.

Upon leaving Arlington, on the night of August 28, Mr. C. F. Mercer, of that city, was requested to make notes upon the damage done to the foliage by the several solutions in experiments 4 to 6, inclusive. These notes were submitted by him in a letter September 1, and the facts contained are included with their respective experiments.

Experiment 4.

August 28 (4:15).—Beer, 8 ounces; cold-water solution commercial arsenic, 4 ounces.

August 29.—Foliage scorched.

Experiment 5.

August 28 (4:45).—Beer, 4 ounces to 2 ounces potassium cyanide solution.

August 29.—Foliage shows no signs of damage.

August 30—No damage to pea vines indicated yet.

Experiment 6.

August 28 (4:55).—Beer, 4 ounces to 2 ounces corrosive sublimate solution.

August 29.—Foliage wilting.

August 30.—Dead and badly damaged.

Notes taken during the progress of the experiments show that recently issued females or those just beginning to deposit do, in fact must, meet with the poisoned liquid on the vines. Soon the moths began to alight upon the leaves or pea pods and sip of the drops of sweets to the practical neglect of the blossoms. After sipping the moths became somewhat uncertain in their flight and soon flew away and hid. It was evident to anyone familiar with their flight that the moths were affected and it was only a question of a short time when death would occur. In fact the day following the first three experiments dead moths could be found here and there when the pea vines were raised from the ground. The specimens were not old or worn-out individuals and their death was evidently attributable to the poisoned liquid which they had sipped from the vines the evening before.

The practicability of this remedy is somewhat lessened by the fact that the poisoned mixture dries rather quickly. To attain the best results it must be applied each day for a time during the egg-laying

period. This objection is valid only to a certain extent as will be noted later. The remedy is certain to be effective if properly managed. Where Boll Worm ravages are very great the additional expense and application upon a minimum area of trap-planted peas becomes proportionately a matter of secondary consideration. The crop which can be most easily and successfully managed for this purpose is that of cowpeas planted in rows 6 or 8 feet apart as a trap bordering the cotton field. They should be planted late so as not to reach the height of their blooming period before the destructive August brood of moths appears. The area should be the minimum and will depend largely upon the size of the cotton field to be protected. The blooming pea vines attract the issuing moths for feeding purposes provided the cotton be early enough to have passed its attractive blooming period. It becomes important, therefore, that the cotton be as early as possible.

As will be seen from the experiments, the difficulty arises that even moderately weak solutions of the poisons scorch the pea vines if the weather be hot and sunshiny. This scorching at once brings to an abrupt end the utility of these plants as a trap crop. This result can be obviated by making the applications as weak as is advisable to insure death to the moths and then only applying it to portions of a row upon any one evening. This leaves unsprayed healthy portions for a series of evenings to follow. Applications should be made to only a portion of each row at any given time, since observation has shown that a moth once starting in a certain row, if undisturbed, is inclined to follow it up or down for some distance. The chances of poisoning are, therefore, greater than were only certain of the rows sprayed and others not at all. In experiments 1 and 4 the same strength of the arsenical solutions was used. In the former the foliage was but slightly injured, in the latter, badly scorched. This is due to the arsenic for experiment 1 having been placed in cold water for about six hours before using, while in experiment 4 it was in cold water for twenty-four hours previous. Hence a greater per cent of arsenic had been dissolved in the latter. A poisoned mixture of arsenic prepared as in experiment 1 and applied while fresh in the proportion of 12 parts of the vinegar solution to 4 of the poisoned liquid will be efficient and yet not injure the vines. From experiment 6 it will be noted that the corrosive sublimate mixture of the same strength as those of experiments 1 and 4 was less immediate in its effects. If the dilutions were carried to the same extent as just advised for the arsenic it could doubtless be used with safety and good results. The experiment with a preparation of potassium cyanide, designated as No. 5, shows that the solution did no appreciable injury to the plants. Since it is a swift poison for insects, its use is undoubtedly effective. There could be no hesitation in concluding from the experiments that preference should be given to the cyanide preparation and its use in the proportion given in the trial recommended were it not for the fact that it was lately determined that there was a

question as to the quality of the substance used. The test of the preparation at Shreveport after the experiments had been made proved beyond question that some cyanide was in solution, but no qualitative test could be made to determine the probable quality of the article used.

There seems to be little, if any choice in the use of beer or vinegar with the molasses. Vinegar and molasses are probably more easily obtainable in the country districts, and hence are the cheapest. Fruit vinegar should be used, and a mixture of 4 parts to 1 of molasses is quite as effective as the ones used in the experiments.

For the application a fine spray is not necessary, as it is preferable that the liquid should be formed in large drops on the plants. Any of the larger spraying machines in use provided with a coarse nozzle can be used for the purpose.

Plates of the poisoned liquids were left standing upon short pedestals among the pea vines, but the moths failed entirely to visit them. Stakes which had been set among the vines were sprayed to excess, but formed no attraction. In fact, anyone who has closely observed the feeding habits of the moth can have no hope for the efficiency of any remedy except an actual application upon the food plants themselves. The usual methods of utilizing poisoned sweets against this pest are evidently useless and involve expenditures of time and money which are practically an entire loss. This conclusion is based upon the behavior of the moths toward the sweets during the egg-laying period. That time over, many individuals may be caught, but then their capture has no real economic significance.

Some advise cutting into halves numbers of ripened melons in patches adjoining cotton fields and saturating the cut surface with poisoned liquids such as have been mentioned. While at Arlington, Tex., a melon patch was found between rows of pea vines and a large cotton field. During the day it was found that where melons had been broken open and left lying during a hot day, Boll Worm moths visited them in the afternoon from about 3 o'clock. The moths unquestionably fed upon the exudations; but the practice is objectionable, since during the day it had been noted that scores of the preying wasps constantly flying about cotton fields, honey bees, and some miscellaneous beneficial insects made visits to the broken melons. All of these would necessarily be poisoned and would be a direct loss. To a certain extent the same objection can be maintained against liquids applied to cowpeas. On these plants, however, the poisoned sweet is not applied until after the heat of the day, when beneficial insects are flying about less plentifully. Furthermore, the application dries the next day as soon as the dew of the night evaporates, which greatly lessens the danger of destroying desirable insects. The drying of the poisoned application is, therefore, in one sense an advantage, as it partially counterbalances the loss in efficacy of the application.

EXPERIMENTS WITH PYRETHRUM.

Simple aqueous decoctions, as reported in Bulletin 24 (pp. 39–44), having proven a signal failure, it was thought advisable to experiment with some of the oils as agents for drawing out the insecticidal element. Headlight oil was selected, for the reason that the quality obtained from country dealers is much more constant and reliable and hence better for a series of experiments. Comparative tests of the power of extraction of the oil by various methods were made, as also of the oil combined in an emulsion with other than oil extracts. As a check upon the pyrethrum emulsions the simple oil emulsion was used in several experiments, in order that the effect of the oil in the combination might be known and any additional advantage of the second factor rendered capable of more definite determination.

SIMPLE EMULSION.

Method of preparation.—Oil 2 parts, water 1 part, and enough soap to emulsify well. Water heated and oil added while the water boiled. Churned until the mixture thickened. Prepared October 8, and is yet in perfect condition November 10. Used in experiments 1, 2, 3, and 4.

As Boll Worms were scarce, the larvæ of the Cotton Worm (*Aletia xylina*) were used in all pyrethrum experiments.

Experiment 1.

October 10 (12:35).—A 4 per cent water dilution was made and sprayed upon larvæ on cotton plants in the field. The larvæ, seventeen in number, were taken from the sprayed plants and placed upon fresh unsprayed leaves in a box, later being placed upon fresh food in breeding cages. This method was followed in all subsequent experiments. The sprayed branches in the field were always appropriately marked, in order that the effect of the emulsions upon the foliage might be noted at any time.

Date.	Living.	Dead.
October 12	1 pupating 10 grown 4 half grown	2 half grown.
Total	15	2

Experiment 2.

October 10 (12:30).—A 6 per cent dilution was sprayed upon 32 larvæ. At 5 p. m. it was noticeable that the younger worms were somewhat affected, but the larger ones showed no uneasiness.

Date.	Living.	Dead.
October 12	4 grown 12 half grown 4 very young	2 half grown. 10 very young.
Total	20	12

The living larvæ less active than those in experiment 1. The foliage in experiments 1 and 2 was examined October 12 and November 23 and found uninjured. The emulsion did not seem to render the foliage distasteful, for young larvæ were subsequently found feeding upon it with a relish.

Experiment 3.

October 24 (*11:15*).—A 13 per cent dilution sprayed upon 12 larvæ; all nearly grown. At 4:43 1 seems slightly affected, others active.

October 26.—All active and have fed freely; two have webbed.

October 29.—Two larvæ feeding vigorously; 1 webbed and 3 pupated.

October 31.—Webbed larvæ all pupated; 1 not perfectly formed.

November 10.—Five imagos have issued. The imperfect pupa is dead, as also 4 others, which do not seem to have been normally formed, due probably to the effect of the emulsion by inducing premature pupation. Foliage slightly injured.

Experiment 4.

October 30 (*4:40*).—A 19 per cent dilution used upon 10 larvæ.

October 31 (*9:30 a. m.*).—Three larvæ badly affected; rest active and feeding.

November 2.—Six are badly affected and will probably die; others feeding.

November 3.—Six are dead, 2 pupated normally, and 2 are attempting to do so.

November 4.—Last two have pupated, but only about half the normal size.

November 17.—Two pupæ are dead; one imago has issued.

December 16.—Remaining pupa produced an imago.

Foliage examined November 10 and found badly scorched.

PYRETHRUM EMULSIONS.

COLD-WATER DECOCTIONS.

Method of preparing first Emulsion.—To one pint of cold water one-fourth ounce of pyrethrum was added, well mixed and left to stand over night in a sealed Mason jar at a temperature of 66° F. This was done at 4:30, October 6. Filtered on the morning of October 7. Of the resulting filtrate one part was emulsified with two of headlight oil and soap as before and left to stand in a sealed Mason jar. This is the emulsion used in experiments 5 and 6. It is worthy of note that on October 10 the simple water decoction which was perfectly clear when filtered had undergone some chemical change—fermentation probably. It became very turbid, offensive in smell, and evidently unfit for further use. On the other hand, the emulsion was still perfect a month later.

Experiment 5.

October 10 (*1:35*).—Four per cent dilution. Number of larvæ sprayed, 16.

October 12.—Both large and small active and feeding. One, about half grown, dead.

Experiment 6.

October 10 (*1:20*).—Seven per cent dilution. Number of larvæ, 21.

Date.	Living.	Dead.
October 12	1 pupa 2 grown 9 half grown	9 half grown.
Total	12	9

Foliage in experiments 5 and 6 uninjured.

The second emulsion was prepared as the first experiment, except that the proportions were 3 ounces of pyrethrum to 1¼ pints rain water. This is the emulsion used in experiments 7, 8, and 9.

Experiment 7.

October 10 (12 m.).—Four per cent dilution. Number of larvae, 16.

Date.	Living.	Dead.
October 12	1 grown .... 4 half grown......... 5 very young	4 half grown. 2 very young. ....
Total	10	6

Experiment 8.

October 10 (11:10 a. m.).—Six and one-half per cent dilution. Number of larvæ, 19.

Date.	Living.	Dead.
October 12	6 grown .... 6 half grown.........	5 half grown...... 2 very young......
Total	12	7

Experiment 9.

October 24 (11:55 a. m.)—Thirteen per cent dilution. Number of larvæ, 10. At 4:37 p. m. 1 larva had webbed, but was badly affected. The other 9 were active and feeding.

October 26.—One pupa, 8 active and feeding; 1 dead, half grown.

October 27.—One more webbed.

October 29.—One more pupa, 4 webbed, and 3 feeding.

November 20.—All but one pupa which was imperfectly formed, have produced imagos. The imperfect pupa is dead. The foliage in experiments 7, 8, and 9 was uninjured.

HOT-WATER DECOCTION.

Three ounces of pyrethrum were added to 1¼ pints rain water, placed in a sealed Mason jar, and boiled for one hour. Filtered and emulsified a portion of the filtrate with headlight oil. This is the emulsion used in experiments 10, 11, and 12.

Experiment 10.

October 10 (11:25).—Four per cent dilution. Number of larvæ, 19.

Date.	Living.	Dead.
October 12........	4 grown.............. 9 half grown......... 2 very young	2 half grown...... 2 very young ....
Total.........	15	4

Experiment 11.

October 10 (*11:05*).—Six per cent dilution. Number of larvæ, 40.

Date.	Living.	Dead.
October 12	1 webbing	6 half grown.
	7 grown............	3 very young.
	22 half grown........	....
	1 very young........	....
Total	31	9

Experiment 12.

October 24 (*12:05 p. m.*).—Thirteen per cent dilution. Number of larvæ, 9. At 4:53 larvæ still active and apparently unaffected.

October 26.—Have fed freely; 3 webbed.

October 29.—One feeding; 5 webbed; 3 pupæ.

November 13.—Two pupated imperfectly and died; others have issued.

COLD-OIL DECOCTION.

One and one-half ounces pyrethrum added to one-half pint headlight oil placed in a sealed Mason jar and left over night at a temperature of 68° F. Filtered the next morning and emulsified the filtrate with half as much rain water. This emulsion was used in experiments 13, 14, and 15.

Experiment 13.

October 10 (*1:05 p.m.*).—Four per cent solution.

October 12.—Three nearly grown larvæ lively; 5 dead, all about half grown. This breeding cage, as also the one of experiment 14, was found to have cracks in, which had been unnoticed, and many of the larvæ escaped.

Experiment 14.

October 10 (*12:55*).—Seven per cent dilution. Late in the evening the larvæ appeared somewhat uneasy.

October 12.—Two half-grown ones may live; 11 half-grown ones are dead.

Experiment 15.

October 24 (*11:25*).—Thirteen per cent solution. Number of larvæ, 10. At 4:25, 4 half-grown larvæ are unable to crawl; 2, about a third grown, in the same condition; 4 nearly grown ones can travel about, though their actions are not perfectly normal.

October 26.—Two trying to web up; 1 larva feeding, and 7 dead. Of the dead, 5 are half grown, the other 2 younger.

October 29.—A Boll Worm in the cage attacked and devoured one of the webbed-up larvæ; the second one pupated, and the third died in the attempt.

November 17.—Pupa has produced an imago.

In experiments 13 and 14 the foliage remained unimpaired, but in experiment 15 it was slightly scorched.

HOT-OIL DECOCTION.

One and one-half ounces pyrethrum added to 1 pint headlight oil, and at 10:45 a. m. the jar was placed in a water bath to heat to a temperature a few degrees short of the point of explosion, namely 170° F. At 11 a. m. a temperature of 160° F. was

reached and maintained for an hour. Filtered while hot into another Mason jar, sealed and set aside to cool. After cooling the filtrate was emulsified as before. This emulsion was used in experiments 16, 17, and 18.

Experiment 16.

October 24 (11:45).—Four and one-half per cent solution. Larvæ, 9 in number. At 5:10 7 larvæ, half grown or over, though quite active, appear slighly affected; 2 are badly affected.

October 26.—Three large ones alive and feeding; another is alive, but not active; 1 has webbed up, and 4 half-grown ones are dead.

October 29.—One live pupa; 2 webbed; 2 dead, including the one which had webbed October 26.

October 31.—Two more pupæ, 1 well formed, the other not.

November 29.—Two imagos issued; the imperfect pupa dead.

Experiment 17.

October 24 (11:35).—Thirteen per cent solution. At 4:48, 3 nearly grown hardly able to crawl. All are evidently uncomfortable.

October 26.—All but one are dead. This one is making a poor attempt at pupating. None fed any before dying.

October 29.—Succeeded in pupating, and is still alive. Later, pupa dead.

Experiment 18.

October 30 (4:15).—Twenty-one per cent solution. Number of larvæ, 10; almost grown. At 4:30 all are off the fresh, unsprayed branches and tumbling about in the cage. All but one are in convulsions; the one exception is not active—in fact, can not crawl.

October 31 (9:30 a. m).—Every effort to place the larvæ upon the branches proves useless today, as it did last evening. The larvæ have not the slightest control of themselves.

November 2.—All are dead. In experiment 16 the foliage was unharmed; in 17 slightly scalded, and in 18 badly scorched.

SIMPLE COLD-WATER DECOCTION.

Three ounces pyrethrum were added to 1½ pints rain water and left to soak over night at 68° F. Filtered the next morning and the filtrate kept in sealed Mason jar. Decoction prepared October 7 to 8. Used in experiments 19, 20, and 21.

Experiment 19.

October 8 (4:55 p. m).—Full strength decoction sprayed upon larvæ of all sizes on a branch of cotton in the field. The smaller ones began dropping off almost immediately. The larger ones showed no desire other than to get away from their moistened quarters.

October 9.—Many worms feeding, some nearly grown, others very young, and but recently hatched, none appearing much affected; 16 larvæ, all less than half grown, dead.

October 10.—Can now tell which ones will survive. Three almost grown, 5 half grown, and 7 very young. The dead numbered 22, all very young and recently hatched.

In experiment 20 only half strength of the decoction was used. This gave even less effective results than the full strength, and need not be presented.

The filtrate of the fresh decoction on October 8 was clear, and had rather a pleasant smell. Subsequently, though kept in a sealed Mason jar, it became decidedly

turbid, formed a precipitate, and has a sour or vinegar-like smell. The pyrethrum smell is but faintly recognizable.

Experiment 21 was made for the purpose of determining any difference in the effect of the changed or fermented decoction and the fresh filtrate.

Experiment 21.

October 24 (12:25).—Full strength applied. At 5 p. m. all the larvæ, 8 in number, lively.

October 26.—All well and active. 2 having webbed.

October 29.—One feeding vigorously, 4 webbed, and 3 pupæ. Evidently no results, and experiment closed.

SIMPLE HOT-WATER DECOCTION.

Three ounces pyrethrum to 1¼ pints rain water, boiled for one hour in a sealed Mason jar. After boiling, filtered and kept filtrate in sealed Mason jar. This decoction was prepared October 8, and used in experiments 22, 23, and 24.

Experiment 22.

October 8 (4:20).—Full strength sprayed upon 49 larvæ. The very young began tumbling off in a few minutes. By 5 p. m. many of the newly hatched larvæ were evidently dying.

Date.	Living.	Dead.
Oct. 10	3 grown 10 half grown 5 very young	7 half grown. 24 very young.
Total	18	31

Experiment 23 was a half strength of the same decoction and, as no special results were obtained, can be omitted.

Though this decoction had been boiled, the filtrate subsequently became turbid and formed a whitish precipitate. Practically in the same condition as the decoction used in experiment 21.

Experiment 24.

October 24 (12:15).—Full strength of the fermented decoction sprayed upon the larvæ. Their behavior in all important respects was the same as of those in experiment 21.

Experiment 25.

October 10 (1:40).—A number of worms were simply sprayed with cold water as a check upon the effect which a forcible wet spray would have upon the very young and half-grown larvæ. Almost immediately occurred the usual dropping off of the very young larvæ and the seeking of dry quarters noted in the other experiments with the aqueous decoctions.

October 12.—All but one half-grown one are quite active and feeding.

Date.	Living.	Dead.
Oct. 19	5 pupæ 1 half young	3 half grown. 7 very young.
Total	6	10

Experiment 26.

As a check on the deaths due to picking and transferring the larvæ to breeding cages, as also upon feeding in confinement, a number of larvæ were picked October 10, as in the other experiments, transferred, and in all respects cared for as the others had been.

Date.	Living.	Dead.
Oct. 12	3 grown 5 half grown	2 half grown. 4 very young.
Total	8	6

The facts contained in the several experiments are tabulated for convenience in Tables XIV and XV.

TABLE XIV.—*Results of experiments with various insecticides.*

Insecticide.	Strength.	Experiment.	Number of larvæ.	Survived. Grown.	Survived. Half grown.	Survived. Very young.	Pupæ.	Dead. Grown.	Dead. Half grown.	Dead. Very young.	Totals. Living.	Totals. Dead.
Oil emulsion	4 per cent	1	17	11	4				2		15	2
	6 per cent	2	32	4	12	4			2	10	20	12
	13 per cent	3	12	7			5				7	5
	19½ per cent	4	10	2			2	6			2	8
Pyrethrum emulsion, cold-water decoction.	4 per cent	5	16	7	8				1		15	1
	7 per cent	6	21	3	9				9		12	9
	4 per cent	7	16	1	4	5			4	2	10	6
	6½ per cent	8	19	6	6				5	2	12	7
	13 per cent	9	10	8			1		1		8	2
Pyrethrum emulsion, hot-water decoction.	4 per cent	10	19	4	9	2			4		15	4
	6 per cent	11	40	8	22	1			6	3	31	9
	13 per cent	12	9	7			2				7	2
Pyrethrum emulsion, cold-oil extract.	4 per cent	13	(*)	3					5			
	7 per cent	14	(*)		2				8	3		
	13 per cent	15	10	2			1		5	2	2	8
Pyrethrum emulsion, hot-oil extract	4½ per cent	16	9	2			1	2	3	1	2	7
	13 per cent	17	6				1	3	2			6
	21 per cent	18	10					7	3			10
Cold-water decoction of pyrethrum	Full	19	37	3	5	7			8	14	15	22
	Full	21	8	† 8							8	
Hot-water decoction of pyrethrum.	Full	22	49	3	10	5			7	24	18	31
	Full	24	(*)									
Check experiments	Cold water	25	16	5	1				3	7	6	10
	Picked larvæ	26	14	3	5				2	4	8	6

* Not counted; see record of experiments in the text.
† See record of experiment in the text.

TABLE XV.—*Experiments with different strengths of pyrethrum.*

Strength.	Experiment.	Number of larvæ.	Survived.			Dead.				Totals.	
			Grown.	Half grown.	Very young.	Pupæ.	Grown.	Half grown.	Very young.	Living.	Dead.
4 per cent	1	17	11	4				2		15	2
4 per cent	5	16	7	8				1		15	1
4 per cent	7	16	1	4	5			4	2	10	6
4 per cent	10	19	4	9	2			4		15	4
4 per cent	13	(*)	3					5			
4½ per cent	16	9	2			1	2	3	1	2	7
Totals		77	25	25	7	1	2	14	3	57	20
6 per cent	2	32	4	12	4			2	10	20	12
6 per cent	11	40	8	22	1			6	3	31	9
6½ per cent	8	19	6	6				5	2	12	7
7 per cent	6	21	3	9				9		12	9
7 per cent	14	(*)		2				8	3*		
Totals		112	21	49	5			22	15	75	37
13 per cent	3	12	7			5				7	5
13 per cent	9	10	8			1		1		8	2
13 per cent	12	9	7			2				7	2
13 per cent	15	10	2			1		5	2	2	8
13 per cent	17	6				1	3	2			6
Totals		47	24			10	3	8	2	24	23
19½ per cent	4	10	2			2	6			2	8
21 per cent	18	10					7	3			10
Totals		20	2			2	13	3		2	18

* Not counted; see record of experiment in text. Larvæ of this experiment not included in the totals.

SUMMARY OF THE EXPERIMENTS.

When studying the above tabulated results it must be constantly borne in mind that the larvæ of Boll and Cotton Worms resist the ordinary liquid insecticides of such strengths as are usually effective against other insects, such as bugs or leaf-hoppers. Another important fact to notice is that whatever effect was obtained from a certain solution or decoction is to be attributed solely to it, since the larvæ were transferred to cages in the shade away from the direct sunlight. The assistance of direct sunlight in producing scorching effects with the oil emulsions is entirely eliminated, and explains why the larvæ seem to have withstood unusually strong solutions. For this reason the results obtained, though possibly less striking, have greater significance as to the real value as insecticides of the combinations made.

The foliage in the field was injured less than might be expected with such strong solutions on account of the cool, dewy nights and moderate temperatures during the day at the time when the experiments were made. It is needless to dwell further upon these conditions, except to state that the same strengths of emulsions if applied during the heat of day in midsummer would affect both larvæ and foliage proportionately in a more decided and vigorous manner. This, however, has no direct bearing upon the primary purpose of the experiments, which was to

discover some easy and practical method of obtaining an extract of pyrethrum, which really added some insecticidal property to the remedy with which it was combined. For this reason in the oil experiments it was manifestly necessary to eliminate the factor of direct sunlight.

In order, however, that this series might be complete in itself a few experiments with cold and hot water decoctions of pyrethrum were repeated. Their results are presented in experiments 19 to 24, inclusive. Comparing these with check experiments 25 and 26 it becomes evident that neither cold nor hot aqueous extracts have any value as remedies against the more mature larvæ, and have but slight utility even against the younger worms. This agrees with what has already been reported in Bulletin 24, p. 43. Results to be of great value in making comparative tests of the remedies should on the whole be obtained by experimenting with older individuals. In the experiments not already discussed considerable selection was exercised in this respect.

The aqueous decoctions of the powder having proven of no value against the more mature larvæ, we should expect to find that the results of these experiments with the oil emulsions combined with these aqueous decoctions would not differ materially from those of the simple oil emulsions of equal strengths. Inspecting Table XVI it is found that experiments 1 to 4, inclusive, were with simple oil emulsions; those of experiments 5 to 12, inclusive, were the same combined with cold and hot decoctions of pyrethrum. In Table XV equal strengths have been tabulated. Noting in this table the experiments just referred to, no appreciable difference is found in comparing experiments 1 with 5, 2 with 6, 8, or 11, 3 with 9 or 12. For a series of independent trials the variation in results is but slight, and the combinations in question seem, therefore, to have no special advantage over the simple emulsion.

Studying next the cold oil-extract emulsions by comparing experiment 15 with 3, 9, or 12, which latter are simple oil emulsions of equal strengths, some difference favorable to the oil extract is shown. The difference can not be fully discussed, since, by an accident, the records of two of the experiments are not complete. It was observed, however, that the activity of the larvæ treated with the oil-extract emulsion was more excited and pronounced than that of those treated with the simple emulsions.

Coming now to the hot oil-extract emulsions, we find some remarkable results. For example, in experiment 16, where a 4½ per cent dilution of this emulsion was used, it is found that grown larvæ were affected to an extent almost equal to a 13 per cent solution of the simple emulsion. Again, in experiments 15 and 17, Table XV, it is found that when 13 per cent solutions of the hot and cold oil extracts were applied to grown larvæ, results favorable to the emulsified hot oil extract followed, the latter killing every larva used in the experiment. The hot oil extract having greatly increased the efficacy of the emulsion, it is to be expected that the cold oil will add to itself, in a less degree and more

slowly, a portion of the active principle of the pyrethrum. The slight advantage of the emulsified cold oil extract over the simple emulsion as already indicated is, therefore, corroborated by the decided advantage of the emulsified hot oil-extract preparation.

The effect of pyrethrum upon larvæ is to throw them into convulsions or paralyze the muscles so that they have no power to direct their movements. None of the emulsified extracts applied to the larvæ produced such effects until we come to the emulsified cold oil applications. In these, the characteristic effects are rather uncertainly indicated in the stronger applications. With the hot oil-extract emulsion such actions were already manifested in the weaker 4½ per cent dilution, and very decidedly in the stronger applications. For example, in experiments 17 and 18, fifteen minutes after the application the full-grown larvæ had utterly lost control of themselves, and it merely became a process of dying from that time. No chance for pupation, as in some of the other experiments.

These facts show that there was really an additional insecticidal effect acquired by the hot oil decoction process, the extract of which was subsequently emulsified.

ADVANTAGES OF THE EMULSIFIED HOT-OIL EXTRACT OF PYRETHRUM.

The experiments above summarized again prove that the ordinary methods of extracting the active principle of pyrethrum are questionable, or at least unsatisfactory. The hot oil experiments show conclusively that this method does to some extent draw out the insecticidal element of the powder, and retains it in the emulsion. However, its use upon host plants which are able to resist without injury an oil emulsion application of sufficient strength to destroy the insect is more expeditious and, perhaps, more economical than the use of the pyrethrum emulsion. But plants which are injured by such an emulsion can be successfully treated with a weaker solution of the pyrethrum emulsion, not injuring the foliage, and destroying the pest as effectually. This is shown by Table XIV, where, with a 4½ per cent pyrethrum emulsion in experiment 16, we have practically the same effect upon the growing larvæ that a 13 per cent oil emulsion has in experiments 3, 9, or 12. The two latter can be regarded as purely oil emulsions, since it has been shown that the aqueous decoctions of the powder really contained no insecticidal properties.

During high temperatures and bright sunshine it is well known that more or less danger of injury to the plant is risked by the use of an oil emulsion when the strength which must be applied comes very near the maximum which the foliage will bear. This risk can be greatly lessened by using the pyrethrum emulsion, because the maximum strength which the plant will withstand need not be approached so closely. This advantage should not be interpreted as a protective effect of the pyrethrum to the foliage, but as an additional insecticidal factor making the usual quantity of oil unnecessary.

HAND-PICKING OF CORN.

In May, from the time when boll-worm injuries are first noticed in the buds of corn plants, the infested ones should be crushed in the hands so as to kill the worms found in them. To determine whether this could be successfully done, the method was tried while taking notes on the number of worms and infested plants in a field during May and June. The result is given in Table I, and shows that of a total of 26 larvæ, 23 (7 half-grown and 16 very young) were crushed. It is therefore a satisfactory process. From the same table it is found that only 2.6 per cent of the plants showed injury. Hence but little time will be required to go over a large field in this manner. After an interval of two weeks, the process should be repeated. This will decrease the numbers of the later broods to such an extent that in many slightly-infested regions nothing further will be necessary, especially if infested ears of sweet corn be burned instead of simply thrown away.

TRAP-CORN EXPERIMENTS.

Experiment 1.

A portion of a plantation owned by Mr. Dan. Nicholson was kindly set aside by him for a trap-corn experiment. The field was rich Red River bottom land, bordered on the east by a large forest, but surrounded on all other sides by cotton fields. Five rows were left vacant on the outer edge of the field, then eighteen rows of cotton planted, four more rows left vacant, then eighteen of cotton, and so on. The cotton was planted at the usual time. Two rows of each of the vacant strips were planted in corn April 4. May 7 this corn averaged about 1 foot in height. No boll worms were found in the buds of the plants, though in a field of corn some 300 yards away, which had been planted at the usual time, a few were collected. This field of early planted corn was near the garden and was surrounded on two sides by fences which were thickly grown over by flowering plants and dewberry vines. As no worms were found some distance from the edge of the field, it was evident that the first brood of moths had been somewhat attracted to the adjoining blossoming plants near the hedge and in the garden, and had confined their deposition to the outer edges of the field. This becomes an important factor when considering the feasibility of resort to killing the first brood of worms in the buds of corn by crushing. This does not apply to larger areas of corn where similar attractions are not near at hand. The trap corn was not so situated, but was in the midst of a large plantation, away from such early inducements.

On July 3 a visit to the trap crop was made. It was, and probably for some days had been, silking profusely just as the second brood of moths was issuing. By July 6 the first planting had passed its prime in point of silking, though still in fit condition to receive the deposition of many eggs. At the time of the July 3 visit the following study of the number of larvæ found in the young ears was made:

Plant.	Ears.	Larvæ.
1	2	6
2	1	1
3	2	4
4	2	3
5	2	7
6	2	5
7	2	3
8	1	1
9	1	7
10	2	2
11	1	2
Total	18	41

The larvæ at this time were nearly all less than half grown, only two of the number being nearly grown. These two were found alone in the ears of plants 2 and 8. In the ear of plant 9, which contained seven larvæ, all less than half grown, two were discovered being eaten by others.

By July 25, the second planting in the remaining two vacant rows was in its prime, but by August 1 had passed its best condition. The time of its greatest attractiveness covered the period of the issuance of the third brood. This brood deposited upon the fresh silks to such an extent as to produce an extremely crowded condition, for the larvæ expected to find food upon such a limited number of ears. Many ears were examined and all presented so nearly the same condition that only a few counts were made. These were:

Plant.	Ears.	Larvæ.
1	1	10
2	2	8
3	3	15
Total	6	33

At the time of this examination, August 1, the larvæ were still all very small, probably two-thirds having never molted. In addition, the ears above noted for the larvæ seldom bore less than six to a dozen fresh eggs upon their silks, often ranging from a dozen to twenty. In the same field, in ears in which nearly-grown larvæ were found, only a few, if any, younger ones were present. This indicates that the crowded condition led the larger and stronger ones to prey upon the others, thus giving the victors more room and food.

The ears of the first planting had now hardened, and no larvæ were found in them and no fresh eggs were being deposited on their leaves and husks. Eggs were still being deposited upon the plants of the second planting. The cotton between the rows of trap corn was carefully examined during the egg-laying period without finding eggs or bored bolls, even in the rows immediately adjoining those of the trap corn.

Experiment 2.

Through the kindness of Mr. A. Curtis, of Curtis, La., a large and fertile tract of land, also in Red River bottom, was placed at my disposal for experimental purposes. The cotton was planted at the usual time, one row for every fifteen being left unplanted. This one row was planted in corn April 9. May 7 the rows of young corn were examined, but no larvæ were found in the plants. A small field of crop corn, planted earlier and joining the experimental field on one side, had a few worms in the buds of some of its plants. The second visit was made July 3, when the corn was found in splendid condition for egg-deposition. The following studies were made of infested ears:

Plant.	Ears.	Larvæ.
1	2	5
2	2	2
3	2	10
4	1	7
5	1	3
6	1	1
7	2	3
8	1	1
9	1	3
10	2	7
Total	15	42

A similar study was made of the adjoining small field of rapidly maturing crop corn, with the following results:

Plant.	Ears.	Larvæ.
1..................	Bored*....	0
2..................	Bored.....	0
3..................	Bored.....	0
4..................	1	1
5..................	2	2
6..................	1	1
7..................	1	0
8..................	1	0
9..................	Bored.....	0
10..................	Bored.....	0
Total...........	11	4

* By bored is meant that a worm had been in the ear but had left, either for another ear or to pupate.

Inasmuch as eggs were found quite plentiful upon the trap corn and none were found upon the other, it is apparent that the moths had chosen between the two.

The number of plants and ears, such as the females would readily deposit upon, was counted. One row contained 148 plants with 267 ears. Each of the remaining rows was of the same length (about 10 or 15 rods) and contained approximately the same number of plants and ears. From the count of the number of worms in the ears of this trap corn, as above given, an average of 2.8 worms per ear is derived. Therefore the above row contained about 747.6 worms. For the eight rows of trap corn in this field, this makes 5,981 as the approximate number of worms trapped. This leaves out of consideration the unhatched eggs found in the silks at that time.

May 23 a second trap planting was made, in a field immediately to the right of the first experimental field. By July 6 it had not yet tasseled, though it was badly infested with another species which was feeding in the buds, just as the Boll Worm does.

Later, about the 1st of August, the second experimental field had silked and was well stocked with boll-worm eggs, many of which were parasitized. The larvæ were plentiful in the ears, and as nothing of further interest could be attached to the experiment, Mr. Curtis cut the corn and fed it for forage.

Experiment 3.

[Mr. J. H. Fullilove's plantation.]

Corn was planted April 13. May 7 it was still small. No Boll Worms in the young plants. Two hundred yards away was a field of corn which had been planted much earlier. In this a few young Boll Worms were found. July 3 the ears of the trap corn were badly infested with Boll Worms and many unhatched eggs were upon the silks. The conditions in general were much the same as in the preceding, and need not be repeated in detail.

Experiment 4.

[Mr. S. J. Ziegler's Plantation.]

One field was rather more upland and less favorable for a good growth of late-planted corn. The first planting of corn was April 9. April 24 the corn was from 4 to 6 inches high, but contained no Boll Worms. It tasseled and silked subsequently and the ears were badly infested.

June 29 the second row was planted. July 28 the plants were 10 to 15 inches high, and had boll-worm eggs upon the leaves. The weather had been very dry during July, and the corn made an unsatisfactory growth, few plants producing ears with large flowing silks.

In another of Mr. Ziegler's fields corn was planted May 19. July 28 this was in fine silk. By actual count the silk of a single ear was found to have twenty-five unhatched boll-worm eggs. Most of the silks had only about a dozen eggs, with from three to six larvæ in the ears.

Late in July notice was received from Mr. John Glassell, jr., a leading planter at Rush Point, La., who had read the recommendations given by the Division upon the boll-worm question, and had prepared to test the suggestion. By his invitation the plantation was visited July 25, and a complete verification of our own experiments proved to be in waiting. Mr. Glassell had planted corn at the time of the second hoeing, when the cotton was about knee-high, or, as he informed me, about May 20. At the time of the visit the third brood of moths was fairly issuing. The trap corn was in fine silk, and the record of a few of the many ears examined will suffice to indicate what they were accomplishing. One ear, 11 larvæ, 7 eggs on silks; another ear, 6 larvæ, 10 eggs on silks. The closest inspection of the cotton plants surrounding this corn failed to reveal any traces of boll-worm injury. Various fields of corn near by were examined but no boll-worm eggs were found. The fresh silking corn was nearly in the center of a number of these fields and seemed to be receiving almost the entire egg deposition of the issuing brood in that immediate locality. Mr. Glassell enthusiastically accompanied your agent during all the observations, with a view of thoroughly informing himself of the facts and enabling himself to estimate the value of this method of protecting cotton. Subsequently he continued to make close observations and reported himself as being well satisfied with the remedy. In this connection it may also be stated that much valuable corroborative evidence was obtained from Mr. S. B. Mullen, of Harrisville, Miss., who had been advised of the trap-corn experiments. He arranged several small fields to make a test of the idea, and all of his reports by letter are in entire accord with what has already been stated.

The plantations thus far considered were bottom lands. The cotton in and about trap-planted fields was practically free from boll-worm injury. This could in a measure be said of other cotton fields in the valley, because the Boll Worm did not appear in destructive numbers during the season. This in reality does not affect the facts recorded for the corn experiments, and their significance relative to the moths which did appear remains the same.

In the "hill country" of Louisiana and portions of Mississippi away from the river valleys, the Boll Worm is not noticed or feared much except during very destructive years, when it spreads from the bottom lands.

A small farm in the uplands west of Shreveport was prepared for experiment in much the same way as those in the valley. Corn was planted May 16. By June 16 it was knee-high, but no worms were found. July 9 corn was tasseling and beginning to silk, but as no moths appeared in this locality, no eggs were found. To trap the first brood requires corn in silk from about May 15 to June 1. This is too early a date to be reached by the yellow or Dent corns. In its stead a sweet corn, commonly planted in the south for table use, meets the requirements. This corn had passed silking and was in good roasting ears before the first of June. Some of the studies made upon it are exhibited in Table II, which shows how badly it was and had been attacked. At the time of the count many unhatched eggs were still to be found upon the silks. Care must be taken, however, not to estimate the abundance of the Boll Worm and the extent of its injuries from such examples. The Dent corns also make an unsatisfactory growth when planted late enough to bring silking about the first of August. In its stead the sweet corn again meets the conditions.

The plan, therefore, to be recommended to the planter for using the trap-corn method of protecting his cotton against boll-worm injury may be summed up as follows: When planting the cotton leave vacant strips

of five rows for every twenty-five of cotton to be planted in corn. At the earliest possible time plant one row of this with an early maturing sweet corn. It should not be drilled in too thickly, since only a minimum number of plants and ears is desired. During the silking period of this corn frequent careful examinations must be made as to the number of small white or brownish banded eggs, hardly larger than a pin head, found upon them. As soon as no more fresh white eggs are found each morning, the silks and ends of the ears should be cut away and fed or burned in order to destroy the young worms and the eggs. A few eggs may be on the leaves of the plants, and since no more growth is to be made, they also should be cut and taken from the field. There is no reasonable objection to this method of handling the first planting, since the natural enemies are not yet numerous and the egg parasites appear in greater numbers during the egg-laying period of the next brood. The next planting should be three rows of Dent corn, drilled in late enough to bring the silking period about the first of July or a little later. These rows catch immense numbers of eggs and larvæ, but should be left to mature in order that the natural enemies which parasitize the eggs and prey upon the larvæ may not be destroyed. Furthermore, the cannibalism previously discussed, which occurs in this corn under such crowded conditions, reduces the number of worms reaching maturity to a minimum, and these can well be allowed to escape if the natural enemies be saved thereby. To trap these escaped individuals, the fifth and last row of the vacant strips should be planted to sweet corn at a time calculated to make it reach full silk about August 1st, when the moths begin issuing again. This expedient allows the planter to save the second planting as a crop. The corn produced in this way is large enough in quantity to pay for the expense of cultivation and management and the sacrifice made in cropping the five rows with corn instead of cotton. However, it must be understood that this is immaterial so long as protection is afforded to the surrounding cotton. The last row of sweet corn should be carefully watched. If it is found that a great many eggs are parasitized, a fact which is indicated by their uniform grayish or blackish color, it may be as well to allow it to mature as before and thus save the parasites. If this condition is not found, the corn should be cut and taken from the fields as soon as it shall appear that no more eggs are being deposited.

If the first two plantings are well managed, the number of the earlier broods will be so reduced that the August brood will not be capable of inflicting great injury, and in less infested regions the third planting may even become superfluous.

It is not necessary or advisable to crop the entire plantation with corn and cotton as recommended. The end will be attained if five-acre strips of alternate corn and cotton be planted for every fifty acres of

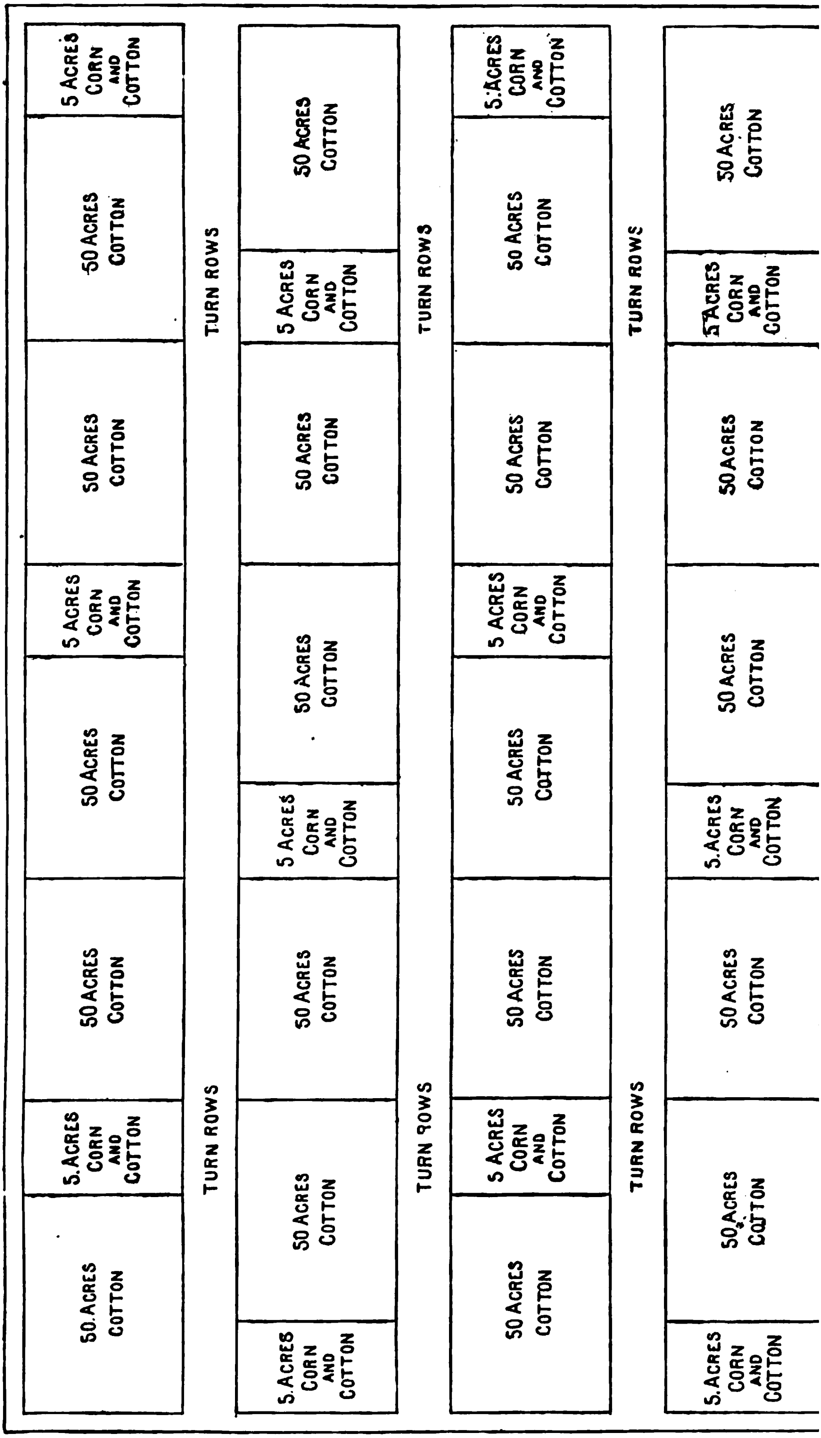


Diagram of Cotton Field, showing location of Trap Corn.

cotton. For less infested regions 5 acres of trap crop for 75 or 100 acres of cotton may suffice to insure the same protection. By a judicious arrangement of the trap crop and cotton lots the five acres of the former may, in the same proportions as above given, be made to act as a protection for just twice the number of acres of cotton above designated. To illustrate this, the accompanying diagram (Plate I) for a plantation of 1,060 acres is presented, and is suggested as probably the best plan for placing the trap corn to the best advantage and insuring the greatest immunity.

On May 27, in company with Prof. Jerome McNeill, a trip was taken to Rustan and Calhoun about 60 miles east of Shreveport. This region is quite heavily wooded, mostly hilly and broken. Along the entire route, often passing beyond the Red River Valley, the crops were at least three weeks behind those of the river bottoms. A similar difference occurs in Texas. Southern Texas is about two or three weeks earlier in point of season than the northern portions. From this great extent of the cotton producing regions, and the variability of the conditions in different localities, it becomes advisable to waive all specific recommendations and depend upon the planter to determine the exact time during which the broods of moths to be feared deposit their eggs in his immediate locality and manage his trap crop accordingly. By way of emphasis and to avoid being misunderstood by farmers, it may be remarked that the time of appearance and egg deposition of the moths is the point in question, and not the worms. Should the farmer base his calculations on the latter, he will fail entirely, since the females will have issued a week or ten days previously and have laid their eggs upon some other host.

The regular crop corn can be protected to a certain extent if care is taken to plant it as early as is expedient, calculating to have it beyond its prime in silking before June 10. If rows of corn near by are planted at a time to bring silking about July 1, the protection to the corn crop will be still more complete. For this reason late planted corn which silks about July 1 is much more eaten by Boll Worms than that planted earlier.

It has already been intimated that the earliest appearances of Boll Worm injury are noticed in patches of early sweet corn in the numerous small gardens throughout the cotton country. These practically form a breeding ground for the first brood. The evident importance of hand picking and destroying the larvæ in these patches is hardly to be overestimated. In fact, it may be quite as practicable to recommend that these small patches be planted with the intention of destroying the corn as soon as an examination of the ears shall show them to be well stocked with worms and eggs. An early planting of sweet corn as a trap crop in cotton will divide the attack upon the gardener's corn intended for the mark and meet this source of complaint as well.

As has been previously noted, the worst infested Boll Worm districts seem to correspond to a certain extent with those regions in which the proportional area of corn is greatest. By some this is put forth as an objection to the trap corn method. The greater acreage of corn results in a greater number of individual ears in which the worms can mature without inducing cannibalism among them. For this reason the first broods succeed in maturing a greater number of individuals which leave the corn when it matures and attack cotton. At the time, therefore, when the trap corn matures and the adults of the destructive brood begin appearing, the properly managed rows of trap corn will be in suitable condition and will attract to themselves the greater portion of the egg deposition. The objection, therefore, is not well taken, but rather, in view of the greater number of the August brood resulting, the adoption of the method recommended, becomes still more imperative. In such districts as those just mentioned it may be advisable to cut out the trap corn and feed or burn it, if examination proves that the egg parasites and natural enemies are not especially abundant upon it. These points each planter must necessarily determine for himself and act accordingly.

EARLY AND LATE COTTON.

While upon a tour of one week in August, in the worst infested region of Texas, the late blooming and maturing cotton (whether the lateness was due to a peculiarity of the variety or to the late planting is immaterial) was almost invariably found to be the worst infested, and often the only infested, cotton in any given locality. In most cases this explains why one cotton field is greatly infested and an adjoining one not, or but slightly injured; the former usually being late, the latter early as to the time of most profuse blooming. Where early and late cottons occur side by side, the latter is at a great disadvantage, for it actually forms a trap crop, attracting to itself almost the entire egg deposition, which otherwise would have been distributed over the two fields.

It is therefore advisable to calculate upon having the cotton as far advanced as possible during July and August, for it must be evident that if the cotton be late and blooming profusely at the time when the destructive broods of those months appear, the attractions of the trap crop will be, to a certain extent, divided. From an entomological standpoint, it matters not whether this be accomplished by planting early varieties of cotton or by planting late varieties early enough to attain the same end.

BACTERIOLOGICAL EXPERIMENTS WITH INSECT DISEASES.

INTRODUCTORY.

The first portion of the work upon the availability of certain disease germs of insects as remedies against the Boll Worm was begun by another, whose report you already have. The writer assumed charge of this work at the close of the season, when it was impossible to accomplish anything further until the following year. Fresh material for further studies could not be obtained, and the cultures at hand, as a result of the outgoing season's labors, were entirely unsafe and unsatisfactory for scientific purposes. The following season the conditions were disappointing, in that the insect upon which the experiments were to be made was not plentiful and the weather conditions were such as to obstruct progress at every step. The laboratory was not complete enough for the most extended and exhaustive researches, and the time at command was considerably divided in attending to other portions of the investigation.

No noteworthy discoveries were made and no reliable ones could be rightfully expected in so short a time. So far as the strictly bacteriological work is concerned, it has just reached a satisfactory basis for exhaustive studies along the lines which the results of the investigation indicate as the most promising.

The studies were conducted as directed upon the practicability of artificially utilizing the germs of insect diseases as remedial agents. Accordingly the germs were isolated as pure cultures by the usual methods and artificial infection experiments made to ascertain the facts. The results as such are entirely satisfactory, though in no sense solving or setting at rest the problem under consideration. Yet, if properly interpreted, they contribute valuable suggestions relative to the basis upon which the problem should be considered, or a solution attempted. The results can not rightfully be taken in a negative sense except in respect to the method and the basis upon which they were obtained.

Practicability having been the object in these studies, only such experiments and observations are presented in this report as bear directly upon that phase of the problem. The minutiæ of some new methods of staining the germs, their specific descriptions, and like matters, are entirely omitted, since, for the purposes of this report, they might be confusing and misleading. If this discussion contributes in any way towards freeing the minds of some from misleading and unbacteriological opinions concerning the problem, or assists in putting future efforts on a more scientific basis, it will serve as great a purpose as our present knowledge of the specific organisms and the attending difficulties involved will permit.

GENERAL PRECAUTIONS.

It will be unnecessary to enter into a detailed description of the laboratory and apparatus used, for both were such as are always required for preliminary bacteriological studies. In general it can be stated that all the customary cleanliness and precautions were successfully observed. The apparatus was thoroughly cleansed after using, and either disinfected or sterilized. Glassware requiring it was placed in sulphuric acid for a time, subsequently washed, rinsed in alcohol, and sterilized. Test tubes in which cultures had been made were first filled with water, again plugged, and boiled for a couple of hours, killing the germs and lessening the danger of accidental infection from escaping spores. After boiling, the tubes were washed quite clean in water and placed in sulphuric acid over night. The following day they were washed, rinsed in alcohol, and sterilized. When making transfers of cultures from old to fresh media, the needles were always first dipped in acid and sterilized, then in distilled water, and again sterilized. To some these may seem to be extreme precautions, but the fact that the sterilizing, filtering, and culture inoculating was all done in the same small room, fully justifies them. That cleanliness and thorough disinfections were constantly practiced, may be concluded from the fact that at no time were any stock media lost through accidental infection or faulty sterilization. At no time was a culture lost through accidental contamination.

The incubator was provided with a thermostat, and the temperature controlled at will for any given purpose or set of conditions.

The infection experiments were carried on in another portion of the city. Two large rooms were fitted up, thoroughly cleaned and fumigated. In one the experiments with the particular microbe under study would be carried on, in the other the check experiments. Six-inch flower pots, covered with netting, were used as cages. These were thoroughly washed with a disinfectant before being employed in any experiment. For each experiment a different pot was used, to avoid the danger of mixing the germs. After each experiment, the room was thoroughly fumigated before another was begun.

CULTURE MEDIA.

Many media could be profitably experimented with in the study of reducing the problem of insect diseases to a practical basis. When, however, immediate practical results are wrongly considered the primary objects and experimentation is inaugurated upon that basis, it becomes impossible to use, at first, more than a few of the standard media. Those used in this work were beef broth, broth agar-agar, broth gelatine, and potato. The two most extensively used were beef broth and broth agar-agar, and for the purposes of this report it will

be sufficient to consider only these two. The following is a brief account of your agent's experience with, and methods of preparing, these two media:

BEEF BROTH.

The formula is the one most frequently used by Dr. S. A. Forbes and Prof. T. J. Burrill, of Champaign, Ill.: One pound of round steak, free of fat, is chopped fine, placed in 1 quart of water, soft preferably, and allowed to stand over night. The next morning the meat is pressed dry. It is well to pour some of the liquid back on the meat, stir up thoroughly, let stand for half an hour, and press again. Strain the liquid through cheese-cloth, measure, and add enough to make the original quantity (1 quart). Pour into a flask, boil in steam, sterilize for an hour and a half. Strain through cheese-cloth or white flannel, filter, and allow to cool. Measure, and if necessary add enough distilled water to make 1 quart. When about 60° C., neutralize with sodium carbonate (or if alkaline, with lactic acid). Cool to about 45° C., and allow to stand for half an hour. Filter. Boil for an hour, cool to 60°, and filter through double thickness of best German filter paper. Sterilize for an hour, and let stand over night. If sediment forms, filter while cold. It is now safe to fill test tubes and proceed with three discontinued sterilizations on as many successive days. In test tubes the sterilizations need not be continued for more than twenty minutes. In large quantities an hour or more is required.

The addition of the neutralizing agent often makes the liquid turbid. Added a little at a time and the liquid shaken, this cloudiness disappears. If so, it only indicates that the liquid is not yet neutral. As the point of neutrality is reached the cloudiness disappears less perfectly upon being shaken, and finally not at all, gradually forming a light, flocculent precipitate. The task of obtaining and retaining an absolute neutrality is a difficult one and the reaction just described, if carefully noted, will be of great assistance in making a delicate test.

Some recommend the use of the white of an egg to assist in clarifying the broth. The method already detailed was so satisfactory that egg was used in only a few instances and then more as an experiment. It was found, if the broth was neutral or alkaline when the white was added, that it coagulated imperfectly when boiled and caused considerable difficulty. The broth had to be acidulated and then boiled to produce the proper coagulation. The filtrate was clear at first, but the process of neutralizing produced the same effect as to cloudiness and fine sediment as already explained.

The white of old eggs is somewhat more liquefied than that of fresh ones, and when used in a quantity of slightly acid broth it was difficult upon boiling to produce perfect coagulation. This merely emphasized the fact that only fresh eggs should be used in the work.

AGAR-AGAR.

In the preparation of this, medium beef broth prepared as already described was used in every instance. For the most part, peptone did not seem to be required in the preliminary studies, and no time was spent in using it to determine additional differences in the growth ot the microbes studied. The agar-agar was finely cut before being placed in the broth to soak. It was found that the difficulty as to cloudiness in the media could be greatly lessened by soaking the agar-agar in water for a time and thoroughly washing before placing it in the broth. With these preliminary explanations, the following may be given as the formula, which is also the one used by Prof. Forbes and Prof. Burrill:

One quart beef broth.
Ten grams agar-agar.
Five grams sugar (yellow clarified).
Five grams salt (druggist's best).

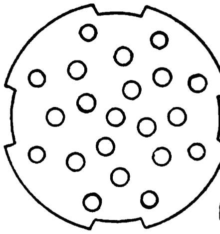
After shaking well, allow to stand and soak over night.

The following morning boil for three hours. Strain until clear; cool to about 60° C. Stir in the white of an egg and boil until well coagulated. Strain until clear; neutralize if necessary; keep hot without boiling, and allow to stand for fifteen minutes. Filter; sterilize for an hour. If sediment forms, filter again; sterilize for another hour, and let stand over night. If upon warming the next morning a sediment forms, filter again, after which it will be safe to fill the test tubes. These are then further sterilized the same as beef broth. After the last sterilization of the tubes the wire cage containing them should be laid on an inclined plane, so as to give a slanting and therefore greater surface in the tube for the growth of the germs.

The agar-agar medium sometimes looks slightly cloudy while yet hot or upon being heated, but, as in the broth, this disappears upon cooling.

SPECIAL APPARATUS.

The filtering of agar-agar and other solid media is often attended with great difficulties in winter, since the hot liquid cools and thickens so rapidly. For this reason an apparatus for hot filtering is necessary. A separate appliance requiring additional gas and burners is in common use. Your agent was compelled to secure the necessary apparatus speedily and economically, and accordingly the following combination of the steam sterilizer and hot filter was devised (see Plate II, Figs. A, B, C, D, E). The lower portion (A) of the sterilizer was made as usual; this particular one 10 inches in diameter and 1 foot high, with three circles of tips (*a*, *a*, *a*) on the inside, on which to lodge the perforated diaphragms (B) at various heights above the water. The legs (*b*) were high enough to allow an ordinary two-burner oil stove to



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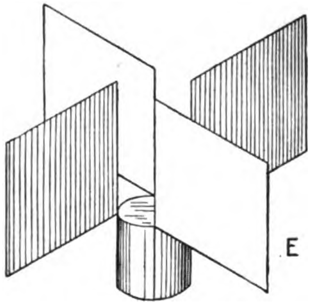

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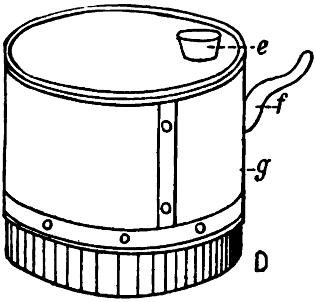

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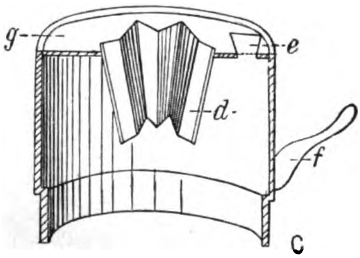

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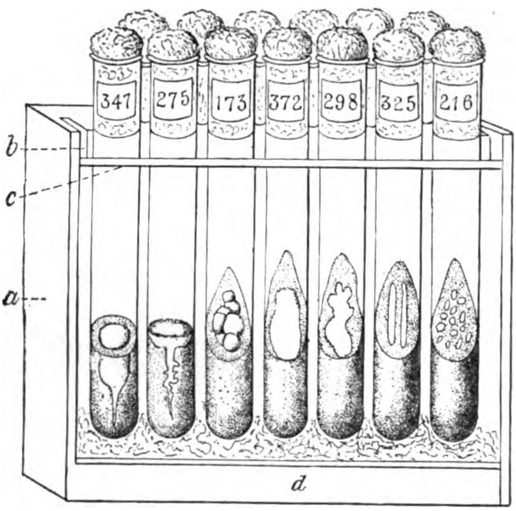

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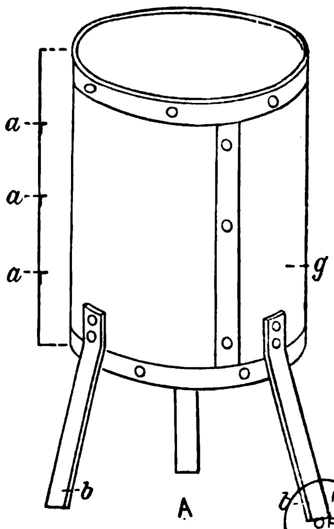

A

SPECIAL APPARATUS FOR BACTERIOLOGICAL WORK.

be placed under. The top or lid (*c*) was made 8 inches high, of the same diameter as the lower portion, fitting into it tightly, so as to avoid the escape of steam and decrease of pressure as much as possible. Through the center of this cover was fitted a collar (*d*) in the shape of an inverted cone, about 3 inches long, 4 inches in the larger and 2½ in the smaller diameters. For this collar a tight-fitting lid like that for a tin pail was provided, in order that the same top might be used either for hot filtering or simply for sterilizing. To one side of the funnel collar, in the top of the lid a second small collar was fitted, for the reception of a thermometer. On the side a slender, slightly bent handle for lifting the top off and on was placed.

When any hot filtering is to be done, the flask containing the medium is placed in the sterilizer and brought to a boil. At the same time a second empty flask is put in on the diaphragm. The top is then placed on. The funnel is provided with the necessary filter paper and the whole inserted through the collar (*d*) in the top of the sterilizer. The steam around the funnel keeps it hot and that escaping through the neck moistens the filter paper. When the liquid to be filtered reaches the boiling point, the flask containing it is taken out, the hot funnel at once fitted through the collar, into the empty flask, inside the sterilizer. The liquid is then poured into the funnel and the filtering proceeds without further interruption or special care. The body of the funnel being inside the sterilizer the steam has full play upon it, keeping it and the liquid almost at boiling during the entire process. At the same time other flasks containing media can be placed in and sterilized while the filtering goes on. The flask receiving the filtrate being in the sterilizer, any danger of falling germs or spores in the air settling upon the liquid is avoided.

The funnel collar should not extend more than a half inch above the level of the top, so as to allow almost the whole of the funnel to be inside the sterilizer.

For some media the pressure of the steam through the funnel checks the rapidity of the filtering. To avoid this a ruffled collar, instead of a perfectly circular one, can be made, thus allowing the escape of steam and relieving the internal pressure. The lid to the collar must be made to fit accordingly. If desirable a plain top (D) can be made for ordinary use in sterilizing, in which case the lid to the funnel collar in the other is not necessary. The respective dimensions must of course be adapted by each maker to his particular purpose. To prevent the radiation of heat as much as possible, the sterilizer is covered or bound in the usual manner with asbestos (*g*).

Another piece of apparatus, which may be called an "incubating cage," Fig. F, was also devised which in many respects materially facilitates work. The cages in which culture tubes are usually placed when transferred to the incubator are the well-known wire cages, holding some twenty or thirty tubes. This entails a great inconvenience

when many cultures are in consideration, since neither the labels on the tubes nor the nature of the growth can be readily seen without taking out each individual tube. This difficulty is overcome in the new cage, the frame of which consists of wooden strips three-eighths or one-half inch thick, and about 1½ inches wide. The two upright ends (*a*, *a*) should be about 4 inches high; with grooves (*b*, *b*) cut along each side into which a plate of glass, *c*, can be slipped. The two uprights are dovetailed into the horizontal piece (*d*), pegged and firmly glued. This done, the two plates of glass are inserted, the bottom covered with cotton to the depth of half an inch, and the tubes placed in as shown in the figure. In doing so the slanting surface of solid media should be turned to the outside and the label placed on the same side. In this way no difficulty is experienced in speedily finding any tube desired and watching from the outside what progress any growth may be making. The cage should be wide enough to receive two rows of tubes, as then there is less danger of its falling over so easily. They can be made any desired length, and the uprights to any height demanded for the best tubes in use.

OBSERVATIONS AND EXPERIMENTS.

June 11 a Boll Worm was placed in a cage to rear in confinement. It fed until June 13, when it entered the earth for pupation, but died in the attempt, June 15. The anterior part of the body began to decay and then darken. At the decaying portion a cut was made dorsally with the proper precautions, and a brownish golden-colored liquid issued. A drop of this was transferred to a tube of broth and a liquid culture made. From this in the usual manner pure cultures were obtained on solid media. The posterior portion of the body did not decompose so rapidly, and though rather spongy, retained its natural color for some time. As the rotting proceeded, the color changed to a brownish or darker color.

The germ which probably caused death changes beef broth to a decided white turbidity, with scant white deposit at first. As the growth advances the deposit becomes more abundant and the liquid begins turning greenish. Finally, the broth clears and is a beautiful deep green, with plenty of white sediment at the bottom. On agar-agar the growth is very thin and scant, beginning by numerous small, irregularly roundish, almost colorless colonies. They gradually spread a little, and if numerous enough form a thin, rather granular-appearing white film. The first pure cultures on solid agar media give the medium a faint, greenish tinge, but this power seems gradually to weaken with subsequent cultures. The germ was found to be quite sensitive to artificial cultivation, and doubtless loses much of its original power by such a process. In some respects the growths upon agar-agar and beef broth are quite similar to those of the cabbage-worm

(*Pieris rapæ*) disease, but a microscopic examination shows the former to be a rather small bacillus.

A similar observation was made June 19, when one of a lot of Boll Worms kept in a breeding cage for life-history purposes was found dead. A bacteriological study was made. The alimentary canal seemed to be the only portion of the body containing much liquefied matter, the fatty portions being rather slow to decay. Pressure of the decaying anterior third of the body forced out a drop of a rather golden-colored liquid, from which a broth culture was made. At the same time a pro-leg was snipped off with sterilized scissors, a platinum needle inserted so as to miss the alimentary canal, and a second tube of broth inoculated. From each pure cultures upon agar-agar were isolated. In the beef broth the changes were the same as just described in the preceding study. Upon agar-agar a more profuse and vigorous growth was obtained, which was partly due to the fact that the tubes had been more recently prepared and were not so dry as in the first study. The film was smooth and white, with margins entire though irregular in some portions.

This affection of Boll Worms is not very prevalent, though occasionally one is found in ears of corn dead or dying. From these in most cases the germ just considered can be isolated by the usual pure culture methods. When affected, the larvæ seem to lose their appetites, cease feeding, become rather sluggish, and appear somewhat disturbed. The color of the skin remains either partly or entirely normal, occasionally even for a time after death. At the same time, however, the tissues of the body are decaying and becoming watery, more especially along the alimentary tract. This condition at last imparts a grayish-brown or rose-tinted color to the body.

Both cultures of this boll-worm bacillus were made from the pure ones on agar, and allowed to grow for eighteen days, when they were used in experiments 1, 2, and 3, which follow.

Experiment 1.

July 8 (*5:30 p. m*).—The husks of an ear of corn were torn aside and the silks and grains for a considerable space were well washed with the broth culture of the bacillus. One nearly grown Boll Worm and one half grown, were placed within the husks, after which these were well closed down upon the ear. The ear was kept in a pot prepared as heretofore explained.

The following day both larvæ had fed freely upon grains of corn which had been drenched with the broth culture. No unfavorable symptoms. The second day the large worm had left the ear and entered the earth for pupation. The small one was still feeding but showed no unhealthy symptoms. The third day the young larva molted. After this it continued to feed in the ear, pupating there and completing its transformations by issuing as a moth July 27. The first pupa had hatched a few days earlier.

Experiment 2.

During the same period of time four cabbage worms (*Pieris rapæ*) were fed upon a cabbage leaf which had previously been well drenched with a portion of the broth

culture used in experiment 1. One of the larvæ was almost grown, one about half grown, and the others younger.

The following day, July 9, the drenched leaf had been almost entirely eaten up. They were left to feed upon the remains until the second day, when a fresh leaf was placed in.

Up to July 14 no symptoms of disease appeared in any of the larvæ, and on that day the last two pupated. July 15 the two oldest pupæ died. One of these had beed noted as turning darker the previous day as if beginning to rot. To-day its wing-covers and head are entirely black, while the abdomen practically retains the normal color. The other dead pupa is entirely of a uniform dusky color. The two living pupæ were lying just alongside the two dead ones, and were thoroughly exposed to infection, if any. Both, however, hatched, one on July 18, the other July 22.

Experiment 3.

July 8.—The culture liquid used was the same as in experiments 1 and 2. A small cabbage leaf was drenched and four *Pieris rapæ* larvæ placed to feed. Two of them were nearly grown, the others about half grown. By July 10 the leaf had been entirely eaten, but no symptoms of disease were noted. Fresh leaves were placed in July 13. July 15 two pupæ were found, one being imperfectly formed. The two remaining larvæ fed freely, but did not seem to grow as rapidly as usual. At times their skin seems to be somewhat puckered and appears rather dusky. July 16 the ill-formed pupa is dead. July 18 the last larvæ pupated. July 27, without any apparent outward changes to forewarn such a result, it was found that all the pupæ had died. About the time of death, or soon after, the color becomes slightly brownish or dusky. The special attention due this experiment was frequently interrupted and fresh food was not provided the larvæ as often, perhaps, as was conducive to their best development. This may have induced them to attempt pupation rather prematurely, or have weakened them so as not to be able to cope with the germ.

Checks on experiments 2 and 3.

The larvæ in experiment 1 having completed their transformations without difficulty, a consideration of its check will not be necessary. For experiments 2 and 3 a number of *Pieris rapæ* larvæ were placed upon cabbage leaves in a separate jar to act as a check.

July 9 the following was the condition of the larvæ in the check: 1 pupated, 3 pupating, 4 grown, 1 half grown, and 3 younger. Up to July 16 the younger larvæ had kept on feeding perfectly, and succeeded in maturing and pupating. Two adults issued on this day, and one pupa, which had been injured a few days before, was dead. July 17, 8 pupæ remained. Two had become darker in color, as if beginning to decay internally. Later these 2 were found to be certainly dead, the one having turned quite blackish, the other more brownish gray. The other 6 hatched.

One of the dead pupæ of experiment 3 was taken for further study. The contents were a blackish liquid mass, from which a drop was taken with which to inoculate a tube of broth. From this other liquid cultures were made, and from these pure cultures upon agar-agar were obtained by the ordinary process. One of the dead pupæ was taken from the check for a similar study. Its contents were of the same nature as of the one just noted. In the same manner liquid cultures, and from these pure cultures upon agar-agar were obtained. A careful comparative study proved that the pure cultures obtained from the two pupæ were identical, and a microscopic study developed the fact that both were cultures of the Micrococcus of the cabbage-worm disease. Accordingly the pupæ in experiments 2 and 3 did not come to their deaths solely through the agency of the boll-worm disease, though the greater per cent of deaths in the experiments, as compared with that of the check, would indicate that the latter germ contributed in some manner to this end

Some diseased cabbage worms were received October 4 from Prof. C. P. Gillette, Ames, Iowa. From one of these larvæ a pure culture of the *Pieris rapæ* micrococcus was obtained. In this condition it was kept in a healthy growing state during the winter by frequent transfers to fresh media. In this manner the germ had been transferred eleven times, nine times on agar-agar and the last two in beef broth. The eleventh culture was used in the experiments August 20, after having had about ten months of artificial cultivation. The culture was two days old when used in experiment 4.

Experiment 4.

August 20.—The culture liquid just spoken of was applied as follows: Two small bolls with involucres were well drenched in the liquid and two half-grown Heliothis larvæ were placed on them. The larvæ began sipping of the liquid, which insured their infection if possible. A small round cavity had been cut into the bolls and filled with the culture liquid. The worms decided to enter the bolls at these injured points, again exposing themselves to infection. Both continued healthy and fed freely, so much so that one fell a victim to the other through cannibalism. The survivor continued healthy to the last, pupated, and hatched later as a robust, active moth..

In isolating the cabbage-worm micrococcus from the diseased larvæ received from Profs. Osborn and Gillette, two other germs were isolated. On agar media the one produces a yellow growth, the other a beautiful pink one. In all the previous and subsequent studies the germ producing the pink growth was almost constantly obtained from diseased cabbage worms. It was therefore thought advisable to give it a trial upon the Boll Worm. A broth culture was made and allowed to grow for two days, when it was applied as detailed in experiment 5. The germ had been carried over winter by artificial cultivations for a period of eight months and was the tenth pure culture.

On agar-agar the growth may be described as follows: At first small elevated round colonies having a translucent whitish appearance. These gradually spread and fuse, forming a continuous white growth. If it continues growing from the margins, these may be finely fringed, slightly branching or corrugated. As the growth becomes thick, the surface becomes very much wrinkled or ridged. At this stage, and often earlier, the growth begins turning to a pinkish color, finally becoming distinctly pink. The pink color appears in smooth growths or isolated colonies, as well, seemingly, developing as the germ ceases its most vigorous growth. The wrinkled scum seems rather to be evidence of a vigorous culture and the result of a very profuse growth.

Experiment 5.

August 15.—The husks of an ear of corn were torn away just enough to expose the silks and grains of corn. The culture liquid was then poured on the tip of the ear and allowed to soak in through the silks and run down the length of the ear. One large Boll Worm and one half grown were in the ear. The liquid came into contact with both, and each was seen to sip of it. The following day the larvæ had eaten plentifully of the corn, including most of the grains which had been drenched with the charged liquid. Both larvæ continued to feed, the larger one pupating and hatching later. The smaller one fed for a time longer, during which no unfavorable symptoms appeared, but finally made good its escape from the pot while searching for a more desirable place to pupate.

The disease of *Pieris rapæ* is found occasionally in most portions of Louisiana, but it is not of a virulent form in most cases, not causing death until the pupal stage is reached. June 8 two dead pupæ of this species were found upon cabbage plants in the field. A careful study

proved that they were not parasitized, and had not been injured. Pure cultures on solid media were isolated from the germs found in the liquid contents of the pupal skins. One of these germs proved to be the cabbage-worm micrococcus. In most portions of the South the disease affects only a small percentage of the larvæ, and as it is usually fully developed only in the pupal form, the contagion among cabbage-worms is reduced to a minimum.

A DISEASE OF PLUSIA BRASSICÆ.

The first symptoms begin to appear about the region of the two white lateral patches just below the median line and over the first pair of prolegs. The patches look like whitish, cheese-like fatty bodies under the skin. From these the pale cream color of the body begins and spreads, the skin gradually becoming entirely of a lemon-yellow color. The posterior portion of the body shows these symptoms first, the anterior portion remaining quite natural in color until about the time of death. No fluids appear to issue from the mouth or vent during the course of the disease. When well affected by the progress of the disease, the larva ceases feeding, dying soon afterward. The entire body deliquesces very rapidly after death, producing a blackish, semifluid mass suspended in a bag of grayish skin, which finally bursts and allows its contents to escape.

September 4, some living Plusia larvæ were found on a cabbage leaf near a dead Plusia larva, which was already black and entirely deliquesced.

Two Plusia larvæ and two of Pieris from the same plant were placed together in a collecting box, and later placed in the same breeding cage to rear. By September 7 the Plusia larvæ had died and deliquesced. The Pieris larvæ had certainly come in contact with the sick Plusia while crawling about and feeding upon the same cabbage leaves, and had thus been thoroughly exposed to infection. Both larvæ, however, completed their transformations, and the butterflies showed no unfavorable symptoms. This experiment was repeated with a greater number of larvæ of each species with exactly the same results.

From this it becomes evident that the Plusia disease could not be very contagious so far as *Pieris rapæ* was concerned; at the same time the disease acts very decidedly and rapidly among Plusia larvæ. They often begin turning pale cream-colored, then yellowish, dying, and the body deliquescing, all within thirty to forty hours. This applies to nearly grown larvæ. Those less than half grown succumb in half that time.

In the usual manner pure cultures were obtained from the dead and deliquescing larvæ. Three distinct germs, two of which were found almost constantly in the several specimens from which cultures were made, were isolated by the usual process. On agar-agar one of these germs produces, at the beginning, numerous small, white roundish

colonies, which gradually spread and form a thin, white granular film, margins wavy or sometimes slightly corrugated. The growth has a slight tendency to liquefy at a certain period of its development. The second produces a pink growth, such as has been noted and described in considering experiment 5. The third is a profuse beautiful yellow growth, beginning at first by dense, thick round colonies, rather whitish at first, but soon turning yellow. When fused and the growth pretty nearly completed it is nearly always quite thick and deep yellow, with margins entire or wavy. The first and third of these are the ones which seem to be constantly associated with the disease. The one producing the thin, white film is the one which is parasitic, or at least partially so, in its relations to *Plusia brassicæ*.

Pure cultures of this germ were also received June 3 from Dr. J. C. Neal, Lake City, Fla. Upon unsealing the tubes a small amount of gas escaped with a fizz, accompanied by a smell reminding one of rotten eggs. Fresh agar cultures were made, and from these, liquid cultures were prepared for use in experiments 6 and 7. The culture liquid used in these experiments was eighteen days old.

Experiment 6.

June 27.—A cabbage leaf was drenched with the charged liquid, and four Pieris larvæ placed on to feed. The day following all were feeding briskly. Two days later the leaf had all been eaten and fresh food was placed in. No indications of disease three days afterward. Later three larvæ pupated, one of which was accidentally injured and died. The fourth larva died, but did not rot or turn dark. It dried up gradually, which indicated that the pot had been too strongly disinfected and that the larva had been poisoned from crawling about its walls. No cultures were subsequently obtained from it. The two living pupæ hatched in due time.

Experiment 7.

June 27.—Two bolls were prepared as described in experiment 4, but using the same culture liquid designated for experiment 6, namely, the Plusia disease germ. Two Boll Worms were placed on, and each was subsequently observed sipping of the liquid. One of the larvæ was full grown, and had shortened some, preparatory to pupation; the other was also about full grown, but fed until mature. Both subsequently entered the earth and completed their transformation without any difficulty.

Checks during the progress of the experiments recorded, and many others were carefully continued. Since no results were obtained from the experiments requiring it, the consideration of the checking will, in this report, be superfluous, save to remark that disease did not appear in them in any instance, except experiments 2 and 3, which have already been included.

DISCUSSION OF THE RESULTS.

From the beginning complicating conditions were discovered. The most important one was that the species in question (*Heliothis armiger*) was subject to a disease which was probably as prevalent as the nature

of the case permitted. Great results had been anticipated by some from an introduction of the disease of the Cabbage Worm (*Pieris rapæ*) as a remedy for destroying the Cotton Catterpillars (*Aletia xylina*) or the Boll Worm. Upon investigation it was found that this disease had already been introduced with its host through the natural dissemination of the disease from the locality of its first appearance. The third complication arose when it was observed that about 80 per cent of the larvæ of *Plusia brassicæ*, a very common cabbage insect in the South, were dying of disease. The importance and relation of these three conditions to each other will be better appreciated by bacteriologists when it is explained that the system of small negro tenantry, which is customary in the greater portion of the cotton district, results in numerous small garden patches along the edges of, and often within, the centers of the fields. The one vegetable which can safely be predicted to be present in nearly all of them is cabbage. These plants were always infested with either *Pieris rapæ* or *Plusia brassicæ*, or both, and concerning both it was known that disease made its appearance. The Boll Worm and Cotton Catterpillar were therefore constantly exposed to the danger of infection. As a consequence, in the studies for the artificial infection of the Boll Worm, the following sources of error required elimination: First, infection through its own peculiar germ; second, through that of *Pieris rapæ*, and, third, through that of *Plusia brassicæ*. This could be best guarded against by determining, as much as possible, the relation of the three germs to the three insects involved. Before these points are discussed, it is advisable to dwell upon some other conditions of environment which will contribute to a better interpretation later.

It is asked, why does not the disease of the Boll Worm itself spread more freely? The diseased Boll Worms, with few exceptions, were found in ears of corn. Here, as has been stated in the first part of this report, a struggle for food, due to crowded conditions, may and often does occur. This compels more or less traveling in search of suitable quarters. This in turn increases exposure to all sorts of unfavorable conditions, including the attack by parasites and natural enemies, as well as disease. Further, having probably fought for its freedom, the larva is forced to change at a time when it is weak and least fit to resist such conditions. It is under these conditions that the Boll Worm sometimes falls a victim to disease, usually, however, getting under the cover of another ear before dying, thereby lessening the chances for its infecting others of its own species. In view of these facts, the trap-corn method recommended in another portion of this report becomes an important factor, in that for this species it furnishes those conditions which are favorable for the greatest propagation of disease.

When the Boll Worm infests cotton, the chances for infection are even more diminished, in that each individual becomes a hermit in addition to feeding on the inside of the cotton boll. Upon cotton they seldom

come in contact with each other. and then for a brief time only. Therefore, should a Boll Worm become diseased upon either corn or cotton, the natural conditions and habits of the past are such that the chances for infecting other individuals through it are reduced to a minimum. This also explains the failure of the disease of *Pieris rapæ* and *Plusia brassicæ* to attack the Boll Worm, and spreading to it through the natural processes of infection and dissemination. On this point, however, another consideration must be noted in the case of *Pieris rapæ*. From the observations already recorded for this disease, it is found that, though present, it developed rather tardily in its host under the prevailing conditions. In addition, it appears to be less virulent and apparently has less power of contagion, since it does not seem to infest others of its own species so readily as in more northern districts, such as Illinois, Indiana, and Iowa. This seems to be due mostly to the differences in climatic conditions, the atmosphere being drier, much higher in temperature, and the hot summer season much more protracted in the South. The well-known devitalizing effect of hot, scorching sun-light under high temperatures upon many bacteriological organisms seems therefore to explain the lesser virulence of this germ in the locality where the investigation was prosecuted. Accordingly, the Pieris disease is unpromising at present as an agent in destroying the Boll Worm in that section. The germ is doubtless becoming more acclimated and adapting itself to prevailing conditions, so that it may be expected to become more efficient in that region in the future.

For the Plusia disease, however, the high temperature seems to be a necessary factor, and, so far as the writer's information goes, is less virulent in the cooler or northern districts.

Experiment 1, in which a pure culture of the boll-worm germ obtained by artificial culture methods was fed to healthy Boll Worms, failed again to produce the disease. The same germ was fed to larvæ of *Pieris rapæ* as detailed in experiments 2 and 3. In experiment 2, 50 per cent died. In experiment 3, all died. Subsequent studies of the dead pupæ in these two experiments, as also the records of the checks upon them, together with microscopic examinations, proved that death could not be attributed to the boll-worm germ with any degree of certainty. On the contrary, death seems to have been due to their own specific germs, as noted in the experiment. Reversing the trial, the germ of Pieris was used in experiment 4, and fed to the Boll Worms without producing disease. The Plusia germ was then fed to Pieris larvæ as in experiment 6, and to Boll Worms as in experiment 7, without bringing about diseased conditions. Furthermore, Pieris larvæ, feeding upon the same plants and leaves along with diseased Plusias, did so with perfect immunity.

What does it all mean? It is unsafe to hazard any positive statements and the discussion must be understood as being provisional. Granting that the germs in question are truly parasitic upon their re-

spective hosts, the first important fact indicated is that they are emphatically specific as to the conditions required for their development. If this be so, the great differences in the life constitution and food of the three species of larvæ under consideration would at once render mutual intercommunication of their respective diseases impossible. The theory held by some that a parasitic germ is readily transmissible from one species to another with power to produce disease, must be dismissed. Experience has shown that producing disease by artificial means in one species furnishes no guarantee that the same germ can in like manner be used to produce disease in a nearly-related species and certainly not for those of distant relations. Actual experiment may prove it to be possible, which should therefore be done before any assertions are justifiable.

The behavior of the germs in question, under the artificial culture conditions recorded in the experiments, indicates that they are facultative rather than true parasites. This means that the germs can and do under certain conditions, develop as parasitic organisms, but under unfavorable conditions can undergo their development in other than living matter and thus tend toward saprophytism. Accordingly they may gradually adapt themselves to being more saprophytic or more parasitic, whichever the prevailing environment may favor. This is quite certainly the nature of these organisms in relation to species of insects other than the one which for convenience may be called the natural host. Therefore the apparently negative results shown in the experiments are negative only as concerns the utility of the germ when used in the facultative condition in accordance with the usual method of procedure. The germs being facultative in their nature, cultivations on artificial culture-media begin at once to weaken their power to produce disease. When a facultative organism, therefore, is used in the usual manner to produce artificial infection, failure is rather to be expected, and it is manifestly erroneous to consider the results as having any direct bearing upon the practicability of parasitic organisms as remedial agents. The only interpretation which should be given the results recorded in the preceding experiments is that to the insect in question (*Heliothis armiger*) the germs cultivated and experimented with, bear only a facultative relation. This fact suggests the abandonment, as a primary method, of the generally accepted one for experimenting with germs in the attainment of practical economic results. This consists in the simple isolation of an organism as a pure culture, feeding it to a given insect, and passing final judgment according to the results which follow. It further suggests that before the question of artificial infection can be satisfactorily solved, the germ used, whether really parasitic or only a facultative parasite, must first be studied in all its relations to environments which allow the organism to produce disease. This done, the next step will be to determine how best to control those conditions by artificial means, either in relation to the host

itself or for fixing upon the microbe a greater power for infection or a coöperation of both upon the same basis. Either cause would result in attaining the greatest infection.

In preparing pure cultures the records show that in the process of isolating the desired germs from the dying host, at least one and sometimes two additional well-defined germs were obtained, which were either associated or coincident with the disease. It is an interesting and important study to determine what are the relations of these germs to each other, either preceding or during the progress of the disease.

Primarily the results of the observations and experiments develop the following facts:

(1) That the germs experimented with are only facultative in their relation to the Boll Worm.

(2) That, as such, in the manner cultivated and in the condition applied, they fail to produce results which are of primary economic importance.

(3) That such failure has no primary bearing upon the availability of strictly parasitic organisms to assist in producing infection by artificial methods and obtaining practical economic results.

Secondarily they rather definitely suggest the following general propositions:

(1) The importance of giving the most exhaustive study to ascertain what environments, as to both the insect and the germ, are favorable or unfavorable to the infection and development of disease among insects.

(2) The importance of first determining the biological character of the organism, *i. e.*, whether truly parasitic or only facultatively so.

(3) The determination of the first and second specifies to a great extent the further method of procedure, and the basis of experimentation.

(4) The importance of the three preceding considerations demonstrates the folly of attempting to obtain practical results by pure cultivations and artificial disseminations, purely as such.

(5) That making the attainment of practical results the primary basis of such investigations is a mistake, and an obstacle to real progress in their final attainment. This suggests that—

(6) The biological and physiological properties of the germs, together with their environments, should first be studied and determined upon a purely scientific basis, without regard primarily to the attainment of practical results.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF ENTOMOLOGY.

BULLETIN No. 30.

REPORTS

OF

OBSERVATIONS AND EXPERIMENTS

IN

THE PRACTICAL WORK OF THE DIVISION,

MADE

UNDER THE DIRECTION OF THE ENTOMOLOGIST.

(PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.)

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CONTENTS.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 25, 1893.

SIR: I have the honor to transmit for publication Bulletin No. 30 of this Division. It comprises the reports of the field agents of the Division for the past year (1892), a summary of which has been included in my annual report.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

REPORTS OF OBSERVATIONS AND EXPERIMENTS IN THE PRACTICAL WORK OF THE DIVISION.

INTRODUCTION.

The present bulletin is a continuation of the series of annual reports of the field agents of the Division, Bulletins 22, 23, and 26 of this Division comprising those for 1889, 1890, and 1891, respectively.

Mr. Koebele's continued absence in Australia up to the middle of the summer, and other duties connected with the closing up of his last Australian mission, have occupied his time to such an extent that no regular report from him is included.

Owing to the reduction in the appropriations for the Division, Mr. F. M. Webster, in Ohio, and the apicultural agent, Mr. J. H. Larrabee, in Michigan, were suspended from duty July 1, 1892. The former was immediately appointed entomologist of the Ohio Agricultural Experiment Station, and has made no report upon his operations as agent of the Division for the first six months of the year.

Mr. Larrabee, however, has sent in a somewhat full report upon the experimental work in apiculture, which is published herewith, and which will be found of interest to apiarists. Accounts of his experiments upon the important questions of cross-breeding, temporary removal of the queen to prevent swarming, the amount of honey consumed by bees in secreting one pound of wax, the cultivation of honey plants, and others, are included.

Mr. D. W. Coquillett, agent at Los Angeles, Cal., reports in full upon his experiments with the beneficial insects received from Mr. Koebele from Australia and New Zealand, giving detailed descriptions of the different states of the species brought over. He also treats of a span-worm (*Boarmia plumigeraria* Hulst), which has lately proved very injurious to Walnut in parts of California, and closes with some account of experiments against the Codling Moth and a few other insects which have been injurious to fruit trees in California during the year.

The Nebraska agent, Mr. Lawrence Bruner, reports upon the outlook for destructive locusts, but devotes the main part of his report to a consideration of certain sugar-beet insects, closing with a short summary of the miscellaneous injurious insects of the season.

The Iowa agent, Prof. Herbert Osborn, gives a general summary of the injurious insects of Iowa for the season of 1892, reports upon further experiments upon grass insects, and gives an account of certain tests made with the White Grub fungus of Europe against our American species.

The Missouri agent, Miss Mary E. Murtfeldt (who was also furloughed at the close of the last fiscal year on account of the reduction in the appropriation), gives in her report an account of certain insects which have been prominent in her vicinity during the season, bringing out, notably, an important point in the life-history of the Cabbage Curculio, and describing a serious attack upon Spinach by a small leaf-beetle.

C. V. R.

REPORT ON SOME OF THE BENEFICIAL AND INJURIOUS INSECTS OF CALIFORNIA.

By D. W. COQUILLETT.

LETTER OF SUBMITTAL.

LOS ANGELES, CAL., *November 3, 1892.*

SIR: I submit herewith my annual report for the year 1892. The major portion of this report consists of an account of the beneficial insects sent to me from Australia and New Zealand by Mr. Albert Koebele under your directions. The caring for these insects and the working out of the life history of the most important ones has consumed a large portion of my time during the past season. The present indications are that the *Orcus australasiæ* will prove of more benefit than any other of these recently introduced species.

Early in the season reports were received of the occurrence in destructive numbers of certain kinds of caterpillars or span-worms, in the counties of Santa Barbara, Alameda, and Santa Clara; and in accordance with your instructions I visited each of these localities, and spent several days in investigating these destructive insects. The species causing the damage in Santa Barbara County proved to be a kind of span-worm which had occasioned considerable injury to the leaves of English walnut trees; an account of this pest is given in the following pages. The principal depredator in Alameda and Santa Clara counties proved to be also a span-worm or canker-worm, closely resembling the well known Fall Canker-worm (*Anisopteryx pometaria* Harr.), but as the moths have not yet issued the species can not be determined at present, but will be reported upon later.

The Fluted or Cottony-cushion Scale (*Icerya purchasi* Mask.), is still held in subjection by the *Vedalia cardinalis*. Since sending in my last annual report I have, at your instance, sent colonies of this useful insect to New Zealand, South Africa, and Egypt, besides sending a large number of colonies to various parts of this State.

The treatment with hydrocyanic acid gas is coming into more general use and continues to be the most effectual remedy at present known for the extermination of the various kinds of scale-insects. The sheet fumigator, described in my letter to you of March 18, and published in the June number of INSECT LIFE, is more widely used than any other kind, being less expensive and easier to operate than those heretofore in use. During the present season the supervisors of Los Angeles County instructed Mr. John Scott, the horticultural commissioner, to purchase seventy tents and the necessary chemicals, and to fumigate the infested trees at cost to the owners. The city of Riverside has also purchased a large fumigating outfit with which to exterminate any scale-insects that may be introduced there, and the citizens of Anaheim, in the adjoining county of Orange, have also purchased a fumigating outfit and have treated nearly all of the infested trees in that vicinity. From the States of Louisiana and Florida I have received letters in relation to this treatment, and

the entomologist of the experiment station in the former State, Mr. H. A. Morgan, recently wrote me that he was making preparations to test it on certain kinds of scale-insects infesting orange trees in his State.

As in former years, I am greatly indebted to you for numerous favors, especially in the matter of identifying insects, for all of which please accept thanks.

Very respectfully yours,

D. W. COQUILLETT,
Special Agent.

Dr. C. V. RILEY,
U. S. Entomologist.

BENEFICIAL INSECTS IMPORTED FROM AUSTRALIA AND NEW ZEALAND.

At the last session of the legislature of this State the sum of $5,000 was appropriated for the purpose of importing from foreign countries beneficial insects that would prey upon the injurious ones found in the State, and this sum having been placed at the disposal of the Secretary of Agriculture at Washington, D. C., Mr. Albert Koebele, one of the agents of the Division of Entomology, was sent on this mission, with instructions to collect specimens of all kinds of beneficial insects and forward them to the writer for propagation and distribution. A large portion of my time has been consumed in caring for and working out the life histories of the insects thus received. Many of the species originally preyed upon insects not found in this State, and much time was spent in testing them with the different kinds of injurious insects found here, in the hope that they could be induced to feed upon them. Eight separate consignments were received at intervals of four weeks, between October 30, 1891, and May 14, 1892. As the majority of these were received during the rainy season, I had three cloth tents erected over as many infested orange trees, the better to protect the insects from the inclement weather.

The first consignment of these insects, collected in the vicinity of Auckland, New Zealand, was received on the 30th of October, 1891, and consisted of two living adult specimens of *Leis antipodum* Muls. and one adult and seventy larvæ of *Scymnus flavihirtus* Brown. The body of this larva is black, and is rather sparsely covered with very short, blunt, white bristles; on each side of the body are several prominent bristle-bearing warts, the three low down on each side of the fourth, eighth, and ninth segments, and also the two on the eleventh segment, being white, the others blackish; the upper one on the eighth and ninth segments is smaller than the others; the head and thoracic legs are dark brown; length 3 mm. The pupa is entirely greenish-yellow, and the old larval skin is worked backward until it covers only the extreme end of the pupa. In the same box with these larvæ were leaves infested with a Coccid which is apparently the *Ctenochiton depressum* Mask., a species thus far known to occur only in New Zea-

land. I tested the above larvæ with specimens of *Aspidiotus aurantii* Mask. and with *Lecanium hesperidum* Linn., and they fed sparingly upon them. The next day I placed these larvæ and the adult specimen upon a tree thickly infested with the Lecanium; this tree I have examined at intervals, but at the last examination did not find any of these ladybirds in any of their stages either upon this or any of the adjacent trees. Still, it is possible that they are established here, but in such small numbers that it is difficult to find them, the insects also being small and inconspicuous.

The two specimens of *Leis antipodum* received with the above I tested with several different kinds of scale-insects, but they did not appear to attack any of them and died on the 20th of the following month without having deposited eggs. All of the other insects which came in this consignment were dead when I received them.

With the above consignment was received, October 30, 1891, the following letter, dated Auckland, New Zealand, October 8, 1891:

By this steamer I send a number of Scymnids, several species, and but two single *Leis antipodum*, which I wanted very badly.

I think it would be a good idea to feed them up at first in large glass jars with *Lecanium hesperidum* and Red Scale; but do as you think best, yet let the insects have light and air besides food,

Please write to me how they arrived and what they feed upon. Let me particularly know about the *Leis*, should they arrive living. Give them *Lecanium hesperidum* and *L. oleæ*. I think they will feed on these, if anything.

As it looks, these little beetles have not much of life in them; they are probably hibernated insects, and through with life; yet the larvæ may be all right. I hope for the best.

Am very well at present and hope to do much better by next steamer. It is too early here as yet, and Sydney I will find warm, if not already hot.—ALBERT KOEBELE.

Under date of November 3, 1891, I wrote to Mr. Koebele, giving an account of the condition of the insects when received by me, and advising him to always pack the insects in Sphagnum moss, as those packed in this manner had reached me in much better condition than had those packed in paper cut into fine strips. As there was no address given in his letter, I simply addressed my letter to him at Auckland, New Zealand, but in the month of May of the following year it was returned to me by the post-office officials, having for some reasons failed to reach him.

The next consignment of insects reached me on the 28th of November, 1891, and the boxes, with the single exception of one from Sydney, Australia, were marked as having been filled at Parramatta, Australia, between the 23d and 30th of October, 1891. With this consignment was received the following letter, dated Sydney, Australia, November 1, 1891:

You will receive by Wells, Fargo & Co. a lot of insects, all Coccinellidæ. Please select an orchard badly infested with the Red Scale, and also some Black Scales, as many of the things feed on this as well as *Lecanium hesperidum*. Turn all the things loose in such an orchard. There are plenty of them to start with.

The large red and black spotted Coccinellid is *Leis conformis*, feeding upon Aphids, which I fear you will not have now; but I send a lot of this to San Francisco to be placed in apple orchards infested with the Woolly Aphis. You will find two boxes with eggs of the little blue beetle. Place them upon trees with Red Scale. This is and will prove to be the best remedy for that scale I shall be able to send. The large blue beetle with orange spots also feeds on this scale. And as to the Scymnid, I have marked upon boxes what they feed on: all the smaller upon *Aspidiotus aurantii*, and one box contains about 90 or 100 of one species found, as yet, feeding only upon a species of Chionaspis, upon a Banksia.

Make preparation, and as soon as the box arrives take them into the field and liberate the insects. A short delay would be death to many of them.

I will run up to Queensland, but will be here again to make up another sending of these beetles for next steamer.—ALBERT KOEBELE.

This consignment contained the following living insects: Four specimens of *Orcus chalybeus*, five of *Orcus australasiæ*, and six specimens of an undetermined Scymnid. All of the other insects, including the eggs and larvæ, were dead when received by me. I tested the living insects with specimens of *Aspidiotus aurantii*, and they fed upon them. Not being willing to turn such a small number of insects loose, as was suggested in the letter, I had a cloth tent erected over an orange tree thickly infested with the above-mentioned scale and placed all of the ladybirds on the tree under this tent. This tree was kindly placed at my disposal by Mr. A. F. Kercheval, of this city.

The next consignment reached me December 28, 1891, accompanied by the following letter, dated Sydney, Australia, November 29, 1891:

Be ready for a large lot of specimens coming per Wells, Fargo & Co. Liberate them in same place as you did the last so they can find each other. Of the two *Orcus* you will receive large numbers; inclosed some of *O. australasiæ* in box with *Lecanium oleæ*, where you may find eggs; also, *O. chalybeus* and a large black Scymnid, which has been, as yet, found only on *L. oleæ* and *L. hesperidum*.

* * * Box "*Vedalia* sp., Toowoomba, Parramatta." Try and breed this little beetle on Icerya. It is the insect destroying this scale here and at Queensland. They will readily lay their eggs in a large glass jar if supplied with scales. You will also get a large lot of *Thalpochares cocciphaga*, both larvæ and pupæ. *Do not set them free*, but breed in confinement in large glass jars covered with muslin and well supplied with *L. oleæ*. * * *

Please save all the boxes with dead insects for me, as I shall want them for future notes. Of course you can have specimens for collection if you should want them. I may now wait in sending future lots of Orcus until I hear from you how this arrived. It is not possible that all should die.

It would be a good arrangement to have three jars for the *Thalpochares*—one to feed the smaller larvæ, one for pupæ, and a third with plenty of fresh food to place the moths in as they appear. The sticks with scales could be taken out from time to time and fastened onto orange trees infested with the scales in the field.

I think that these larvæ attain their growth in from three to four weeks. They are a stupid lot, always spinning everything together. Therefore it would be well to give them plenty of room.

The larvæ of Orcus could be got by the thousands, but I can not send any on account of the parasites.—ALBERT KOEBELE.

In this consignment were the following living insects: Three specimens of *Orcus chalybeus*, one *Orcus australasiæ*, eleven undetermined

Scymnids, one hundred and seventy-five specimens of *Alesia fromata*, twenty-four specimens of a large, reddish-yellow Coccinellid having six irregular spots besides the elytral suture black, three specimens of *Novius kœbelei*, twelve small black ones having a large red spot on each elytron, twenty-two specimens of a black Scymnid having only the apex of the abdomen red.

I tested them with a great variety of different kinds of insects, and ascertained that the Alesia—the yellowish one with six elytral black spots—the Cryptolæmus, and the black one with two elytral red spots, all fed upon the Cabbage Aphis (*Aphis brassicæ*). Accordingly, I turned them loose in a field of cabbages thickly infested with these Aphides. The Novius I placed in a jar containing Iceryas; the remaining specimens I placed on the orange tree under the tent where I had placed the previous consignment.

On the 30th of December, 1891, I wrote Mr. Koebele as follows:

The two packages of insects which you sent me from Sydney reached me in very poor condition. In your first sending were only four living *Orcus chalybeus*, and in the last sending three. Of *Orcus australasiæ*, five were alive in the first lot, but only one in the last. As these are the two species that we look to for ridding the infested trees of the Red Scale, it would be well to pay especial attention to them in your next sending. Try especially to send the pupæ, as these withstand the voyage better than the adult beetles. The square boxes with sliding lids are better for sending them in than are the smaller circular ones. I noticed that those packed in Sphagnum moss came through in better condition than those you packed in paper cut into strips. A good plan would be, to place in the bottom of the box a thin layer of damp Sphagnum, then twigs infested with the scales, after this the ladybirds, placing on the top another thin layer of Sphagnum.

Packages intended for me should be addressed to me at 236 Winston street, so that the express company will not have any difficulty in delivering them.—D. W. Coquillett.

The next consignment of insects reached me January 23, 1892, and was accompanied by the following letter, dated Sydney, Australia, December 28, 1891:

A lot more of Coccinellids, to be let loose in same place as previously. Also a number of things in one box, to breed in confinement. Do not open boxes outside of room or with open windows. The parasites will not only destroy these larvæ, but all or any Coccinellid. I hope you see the point, and I trust to you not to let any escape. Also, more larvæ and pupæ of *T. cocciphaga*. Feed Coccinellid larvæ from Whitton on Lecanium, as also those of *O. australasiæ*.

Why did you not write about the New Zealand insects?—Albert Koebele.

In this consignment were four hundred living adults of *Orcus chalybeus*, seventy-five of which I placed on the orange tree under the tent, and liberated the remainder in the orange grove adjoining this tree, this grove being very thickly infested with *Aspidiotus aurantii*. The consignment also contained forty-five adults and thirty-six living pupæ of *Orcus australasiæ*; twenty-two of these I placed on the orange tree under the tent, while the balance were placed on an ash tree thickly infested with *Lecanium oleæ*. I retained the pupæ in my office until

the beetles issued, then placed the latter on the ash tree above mentioned. Besides these, there was also a package of twigs on which were numerous specimens of *Lecanium oleæ* infested with a fungus; these I placed on an oleander bush thickly infested with the above-mentioned Lecanium. The package also contained eight large black Scymnids, which fed sparingly upon *Lecanium oleæ*, and I therefore had a tent erected over an orange tree thickly infested with these scales, and placed the Scymnids in this tent. This tree was placed at my disposal by Judge E. Silent, of this city.

I received the next consignment on the 20th day of February, 1892. It was not accompanied by any letter. The entire package was completely soaked with water when it reached me, and several of the boxes were broken open. This consignment contained eight living adults of *Orcus chalybeus*, which I liberated in the same orange grove where I had placed those of the previous sending; twenty-three Scymnids, which I placed on the orange tree infested with *Aspidiotus aurantii*, under the tent, and thirty adults of *Orcus bilunulatus*, which I placed on the orange tree infested with *Lecanium oleæ* under the tent at Judge Silent's.

The next package of insects reached me on the 21st of March, 1892, and was accompanied by the following letter, written at Sydney, New South Wales, February 22, 1892:

> I have your letter of December 30. Sent a lot more of Orcus and a small Scymnid on Red Scale; this latter is as good as Orcus in destroying these scales.
>
> In box with Eriococcus you will find some Scymnids feeding on Black Scales, also their larvæ, larvæ of Thalpochares and of a Pyralid (?). This latter you had before. They may feed on Lecanium. Breed all these in confinement, and not get box near Eucalyptus. A whole box full of Lecanium with internal parasites. You had better not place them on trees, but at a distance from them, as, if necessary, in case the Scales should establish themselves, they could be promptly destroyed. The same may be said of the Eriococcus, which, although only feeding on Eucalyptus, is a bad thing on these trees.
>
> Await *Leis antipodum* and rear on *Lecanium hesperidum*.—A. KOEBELE.

This package did not contain a single living insect when I received it. Among the dead insects was a ladybird larva which I recognized as belonging to *Scymnus lophanthæ* Blaisdell, a species which had evidently been imported into this State from Australia several years ago, and upon procuring specimens of the larvæ of this ladybird from orange trees in this city I found that the two forms were identical. The package also contained dead specimens of a ladybird which agree in every particular with specimens of the above-named Scymnus contained in my collection and which were captured in this city several years ago. Specimens of both were submitted to Dr. Riley in order to settle this question definitely, and he writes me that the two forms, the one received from Australia and the other collected in this city, are indistinguishable, and that both belong to the species recently described by Dr. Blaisdell as *Scymnus lophanthæ* (see "*Entomological News*," vol. III, p. 51). I gave a description of the larva and pupa of this ladybird in

Bulletin No. 26, Division of Entomology of the U. S. Department of Agriculture (pp. 16 and 17), where it is referred to as "an undetermined species of Scymnus, closely related to *Scymnus marginicollis* Mann., but having a distinct metallic, somewhat brassy tinge upon the wing-cases." I have found this larva feeding upon the Red Scale (*Aspidiotus aurantii*) as well as upon the San José Scale (*Aspidiotus perniciosus*) and the Woolly Aphis (*Schizoneura lanigera*). This is doubtless the "small Scymnid on Red Scale" referred to by Mr. Koebele in the letter given above and which he says is "as good as the Orcus in destroying these scales," the other Scymnids referred to being much larger species.

Another package of insects from Sydney, Australia, was received on the 15th of April, 1892. No letter accompanied this package, which contained the following living insects: Twenty-seven specimens of *Orcus chalybeus* and nine of *Orcus australasiæ*, all of which I liberated in the orange grove in which the former consignments were set free; four specimens of *Leis conformis*, and five of the large yellow Coccinellid with six elytral black spots, which was also represented among those received December 28, 1891, and alluded to above. The specimens of the last two species I placed on an orange tree thickly infested with Aphides. There was also a box containing a number of larvæ and chrysalides of the moth *Thalpochares cocciphaga* in their cocoons; these I placed in breeding cages in my office and kept them well supplied with *Lecanium oleæ*. During the month of May nine adult parasites belonging to the genus Bracon issued from these larvæ or chrysalides. The moths issued in the latter part of June and during the month of July, and after the last one had finished depositing her eggs I placed the entire contents of these cages in an orange tree thickly infested with *Lecanium oleæ*.

The eighth and last consignment of insects from Sydney, Australia, reached me on the 14th of May, 1892. This package also was not accompanied by letter. For the first time, all of the insects had been packed in Sphagnum moss, as advised in my letter to Mr. Koebele, of December 30, 1891, a copy of which is given on a preceding page, and the insects reached me in much better condition than did those of any previous sending. This package contained 560 living specimens of *Orcus chalybeus*, 20 *Orcus australasiæ*, 170 specimens of *Leis conformis*, and 5 specimens of the yellow Coccinellid with six elytral black spots. I retained 20 of the *Orcus chalybeus* and 10 *Orcus australasiæ*, for breeding in my office; the remainder I turned loose in an orange grove, in this city, thickly infested with *Aspidiotus aurantii*, *Lecanum oleæ*, and a certain kind of *Aphis*. The specimens ot *Leis conformis* I liberated in an apple orchard, in this city, thickly infested with the Woolly Aphis (*Schizoneura lanigera*), while the yellow ladybirds with six elytral black spots were kept in my office, in a large glass jar well supplied with Aphides. On the 28th of May a parasitic larva issued from the under part of the body of one of the last-named ladybirds, and spun its tough brownish cocoon beneath the latter, thus attaching the ladybird to the surface upon

which it rested, and the adult fly issued from this cocoon eight days later. On the 30th of May another parasitic larva issued from a second of these ladybirds, and spun its cocoon as the previous one had done, and the winged parasite issued seven days later. I submitted both specimens of this parasite to Dr. Riley for identification, and he writes me that they agree in every particular with specimens of *Euphorus sculptus* Cr. in the collection of the National Museum. It is interesting to note that on page 57, volume III, of INSECT LIFE, Dr. Riley records having bred this same species from adults of the native ladybird, *Megilla maculata*, collected at Washington, D. C., and also at La Fayette, Ind.; while here in California I have bred what he pronounces to be this same species from two of our common ladybirds, *Hippodamia convergens* and *Coccinella sanguinea*, both of which are also found in the eastern part of this country. Thus this parasite is known to occur on both sides of this continent as well as in Australia. With the above-mentioned package was received a box of *Aspidiotus aurantii* infested by a fungus; these I placed in an orange tree thickly infested with this kind of scale-insect.

As stated above, no insects were received by me from Mr. Koebele later than the 14th of May, 1892.

The following are my notes and descriptions of the early stages of some of the insects received from Australia. These are not complete in regard to all of the species, since a sufficient number of specimens of several of the species was not received to permit of my making descriptions of all the stages, and I was unwilling to hazard the life of any of the larvæ belonging to species not thoroughly established here by submitting them to repeated and critical examinations such as it would be necessary to make in order to describe the various stages through which these insects pass:

ORCUS AUSTRALASIÆ.—*Egg.*—Elongate-ellipsoidal, two and half a times as long as broad, polished, but slightly scabrous, one end bearing numerous minute tubercles; color, light lemon yellow; length, $1\frac{1}{4}^{mm}$. Deposited beneath dead, empty specimens of *Lecanium oleæ* partially raised from the surface upon which they rest; usually deposited in pairs, the eggs being attached at one side to the under surface of the scale.

Time from deposition to hatching, eighteen days.

Larva.—First stage.—Body brownish black; first segment encircled in front and on the sides with a row of fourteen small tubercles each tipped with a single bristle, except two of the lateral ones each side, each of which bears two bristles. There is also a pair of smaller subdorsal bristles near the posterior end of this segment; second segment bearing twelve tubercles, arranged on each side of the segment, one subdorsal, three suprastigmatal arranged in the form of a triangle, and two stigmatal tubercles placed one in front of the other, the anterior of these being much smaller than the posterior one, and destitute of a bristle. Each of the other tubercles bears a bristle which is more than twice as long as the tubercle itself, except the anterior of the three arranged in the form of a triangle. This bears two bristles: one, which is shorter than the other, is inserted below the apex on the front side, at which point this tubercle bears a minute branch; third segment like the second, except that the upper of the three tubercles in the triangle is wholly wanting, leav-

ing only ten tubercles on this segment; fourth segment bearing a tranverse row of six tubercles, the subdorsal ones each bearing two bristles, the second of which is inserted below the apex on the front side; each of the suprastimatal tubercles bears three bristles, two of which are inserted below the apex, one on the front side and the other on the outer side; the lowest tubercle bears but a single bristle; fifth to tenth segments, like the fourth; eleventh segment like the fourth, except that the lowest tubercle on each side is wanting, leaving only four tubercles on this segment; twelfth segment destitute of tubercles; head wholly black.

Duration of this stage, six days.

Second stage.—Body brownish black, a yellow dot on the posterior margin of the first segment; a larger medio-dorsal yellow spot on the second, third, seventh, and eighth segments; tubercles black, except the posterior four or six on the first segment, all of those on the second, all except the lowest ones on the third, all on the seventh and eighth, and all except the lowest on the ninth segment, which are largely or wholly yellow; sometimes, however, the lowest tubercles on the second, seventh, and eighth segments are black; first segment encircled in front and on the sides with a row of sixteen long tubercles, each of which bears a long apical and several shorter lateral bristles; there is also a small, yellow subdorsal tubercle each side of the middle, near the posterior end of this segment, each tubercle bearing a bristle which is three times as long as the tubercle itself; other tubercles arranged as in the first stage, each bearing an apical and several lateral bristles, the apical one not appreciably longer than the tubercle itself, except in the case of the tubercles situated lowest down on each side of the body; the anterior of the two lowest tubercles on the second segment is scarcely more than half as long as the posterior one; the anterior of the two lowest tubercles on the third segment is minute and scarcely apparent; head entirely black.

Duration of this stage, seven days.

Third stage.—Marked as in the second stage, except that all of the tubercles on the ninth segment and the subdorsal ones on the tenth are yellow; tubercles arranged as in the second stage; the subdorsal tubercles near the posterior end of the first segment are now much larger, being scarcely shorter than the bristles at their apices; the anterior of the two lowest tubercles on the third segment is scarcely one-sixth as long as the posterior one, and is yellow; the four tubercles on the eleventh segments are noticeably longer than any of the others.

Duration of this stage, eleven days.

Fourth stage.—First segment yellow, the center above, including the greater portion of the space inclosed by the tubercles, black; second segment black, the anterior and posterior margins and the sides broadly yellow, that on the posterior margin being produced forward in the middle above; third segment yellow, marked with a pair of black spots in front and with a second pair behind the subdorsal tubercles; there is also a black spot in front of the upper of the two lateral pairs of tubercles, and another at the base of the posterior of the two lowest tubercles; fourth, fifth, and sixth segments black, marked with an irregular silvery-white stripe between the tubercles, the sutures of these segments yellow; seventh segment silvery-white, marked with a small black spot between the two upper tubercles and with a larger one behind the upper of the two lateral tubercles; eighth segment black, the greater portion of the space between the subdorsal tubercles silvery white, and there is also a spot of the same color at the base of the lowest tubercle; ninth segment black, the middle of the posterior margin, extending nearly as far as the upper of the two lateral tubercles, silvery white; tenth segment black, the posterior margin silvery white, which color crosses the segment obliquely between the subdorsal and the upper of the two lateral tubercles; eleventh segment like the tenth, except that there is a silvery-white spot at the base of the lower tubercle; twelfth segment wholly black; there is also a silvery white medio-dorsal line extending from the

second to the eight segment; venter yellow, the abdominal segments marked with dusky black; tubercles arranged as in the preceding stage, black, all of those on the first, second, seventh, eighth, ninth, and tenth segments yellow, as are also those on the third, with the exception of the posterior of the lowest two; the lowest tubercle on each side of the sixth segment is also yellow; the subdorsal tubercles near the posterior margin of the first segment are nearly as large as those on the sides of this segment; the anterior of the two lowest tubercles on the second segment is slightly longer than either of the three arranged in the form of a triangle above it; the anterior of the two lowest tubercles on the third segment is not half as long as either of the two above it; except on the first segment, none of the bristles are as long as the tubercles which bear them; head black, marked in the middle with a yellow spot. Length, 8^{mm}.

Duration of this stage, eleven days.

Pupa.—Yellow, marked with a medio-dorsal row of oval black spots, one to each segment, and on each side of these is a row of larger black spots, one to each segment, except the first, those on the second segment sometimes connected along the front end of this segment with the median spot; wing-cases entirely, or at least their upper edges, black; entire surface thinly covered with a yellowish white, appressed, scaly pubescent; first and second segments bearing several short, erect bristles; remaining segments each bearing a large cluster of bristles in the subdorsal and also in the stigmatal region; length, 7^{mm}.

Duration of this stage, eleven days.

In pupating the old larval skin is rent along the back from the head to the front end of the eighth segment.

The time passed by this ladybird in its preparatory stages from the depositing of the egg to the issuing of the adult insect is seen to be about sixty-four days, divided as follows: Egg, eighteen days; larva, thirty-five days (first stage, six days; second stage, seven days; third stage, eleven days, and fourth stage, eleven days); pupa, eleven days. These periods are for the months of August and September, the insects having been bred in breeding cages kept in the window of my office, where they received the benefit of the afternoon sun. It is probable that in the open air they would have passed through their various changes in a somewhat shorter period of time than that indicated above.

On the 14th of May of the present year I placed in one of my breeding cages, 10 of these ladybirds received that day from Sydney, Australia, and kept them well supplied with specimens of *Aspidiotus aurantii*, *Lecanium oleæ*, and various kinds of Aphides, but more than six weeks elapsed before any eggs were deposited. At certain intervals after this I removed the larvæ from this cage, and placed them on an orange tree thickly infested with *Aspidiotus aurantii* and *Lecanium oleæ;* on the 16th of August I thus removed about 100 of them, on the 5th of September 13 more, and on the 28th of September I placed the entire contents of this cage on the same orange tree. At this latter date several of the beetles originally received from Australia were still alive, which would indicate that they are comparatively long lived, since I had them in my possession for a period of over four months, and they may have been several weeks old at the time of their capture in Australia.

ORCUS CHALYBEUS.—*Egg.*—Elongate-oval or elongate-ellipsoidal, from somewhat over twice to nearly three times as long as broad, surface polished, the upper end scabrous and on one side of the middle bearing a white, flattened, branched process, having somewhat the appearance of an antler of a Moose-deer; color of egg, light lemon yellow; length, $1\frac{1}{4}^{mm}$. Placed on one end in clusters of from 4 to 10 eggs each.

Time from deposition to hatching, eight days.

Larva.—First stage.—Body yellow, the tubercles dusty; first segment surrounded in front and on the sides by a row of ten long tubercles, and with a transverse pair of much smaller tubercles on the dorsum near the posterior end of this segment, each of these smaller tubercles being as broad as long; second segment bearing a transverse pair of long tubercles, each size beside a dorsal transverse pair of much smaller tubercles, and a single small tubercle in front of each of the lowest tubercles on this segment; each of these small tubercles is as broad as long; segments three to eight, each bears a transverse row of six long tubercles; segments nine and ten each bears a transverse row of four long tubercles; eleventh segment bearing a single transverse pair of long tubercles; twelfth segment destitute of tubercles; each of the small tubercles above mentioned bears a single long bristle at its apex; each of the long tubercles is truncated at its apex, where it bears a stout bristle which is usually longer than the tubercle itself; in addition to this, the second tubercle on each side of the middle of the dorsum on the second and third segments bears a second long, stout bristle on its outer side a short distance below the apex; each of the long tubercles also bears one or two short lateral bristles; the surface of the body is thinly covered with minute tubercles, each giving rise to a very short yellowish hair; head light yellow, thinly covered with slender bristles and bearing three black ocelli each side in the form of a triangle.

Duration of this stage, six days.

Second stage—Same as in the first stage with the following exceptions: Each of the small tubercles in the transverse subdorsal pair near the posterior end of the first segment, as well as those in the subdorsal pair on the second segment and the foremost one of the two lowest on each side of this segment, is nearly three times as long as broad; each of these smaller tubercles bears a single apical bristle which is slightly longer than the tubercle itself, and each of the remaining one bears a pair of apical besides several lateral bristles of various lengths, but none of them are as long as the tubercle itself.

Duration of this stage, six days.

Third stage.—Same as in the second stage, with these exceptions: Dorsum of segments two to nine black, most extended on the second and third segments; the tubercles in the dorsal pair near the posterior end of the first segment and also those on the second segment are nearly as long as the adjacent ones, being somewhat more than four times as long as broad, but the anterior of the two lowest tubercles on each side of the second segment is still much shorter than the others, and is scarcely over two-thirds as long as the posterior one; each of these tubercles bears several short lateral bristles.

Duration of this stage, seven days.

Fourth stage.—The black of the dorsum is extended so as to include four rows of tubercles, and on the second and third segments it is divided by a medio-dorsal yellowish line. There is also a yellowish line on segments four to nine between the first and second rows of tubercles each side. The black coloring on the outside of these lines is not so intense as it is within them. The anterior of the two lowest spines on the second segment is five-sixths as long as the posterior one. Otherwise as in the preceding stage. Length, when fully grown, 5^{mm}.

Duration of this stage, fourteen days.

Pupa.—Light citron yellow, head almost surrounded with blackish, first three segments each marked with a pair of oblique black dorsal spots, those on the second segment the largest; fourth segment marked with a pair of small black dorsal dots

which are scarcely apparent; segments five to eight each marked with a pair of black dorsal spots, those on the sixth and seventh segments larger than the others; wing-cases bordered above with black; surface thinly covered with a light yellow pubescence; length, 5^{mm}.

Duration of this stage, fourteen days.

From these data it will be seen that this species passes through its various stages in a somewhat shorter time than is the case with *Orcus australasiæ*. In all of its stages it is much more delicate than the last-named species, and the beetles appear to be much shorter lived. On the 14th of May I placed twenty adults of *Orcus chalybeus* in one of my breeding cages and kept them well supplied with specimens of *Aspidiotus aurantii* and *Lecanium oleæ*, but no eggs were laid until about two months later, or on the 25th of July; and the last beetle in this cage died on the 2d of August. Specimens of *Orcus australasiæ*, obtained at the same time as these and treated in the same manner, were still living nearly two months after the last *chalybeus* had died.

On the 10th of August a larva of *chalybeus*, only four days old, was attacked by a whitish, feathery fungus which spread out on all sides of its body, giving the latter the appearance of resting upon a miniature mat of feathers. I submitted this specimen to Dr. Galloway, the mycologist of this Department, by whom it was referred to Mr. J. B. Ellis, a well-known authority upon fungi, who reported that this fungus was either the *Microcera coccophila*, or else a species of Isaria, probably the latter. The Microcera here alluded to is known to attack various kinds of scale-insects in Australia, and it would be interesting to learn if the spores of this fungus were brought over with the ladybirds recently imported from that country; but a second letter to Dr. Galloway upon this subject elicited the fact that the specimen in question had been mislaid and could not be found.

NOVIUS KOEBELEI.—*Egg.*—Elongate-ovate, two and a half times as broad, the surface very scabrous; color, deep orange-red; length, 0.75^{mm}. Attached lengthwise to the body of an Icerya, or thrust into the egg-sac of the latter.

Time from disposition to hatching, six days.

Larva.—*First stage.*—Body, including the head and legs, blood-red, the first three segments each marked with a pair of subdorsal black spots, those on the first segment the largest; first segment bearing four long bristles, two on each side, besides two shorter ones near the front end; second segment bearing a transverse pair of bristles each side, of which the upper bristle is the shorter; third segment like the second; segments four to nine, each bearing a single long stigmatal bristle each side, which springs from a small black tubercle; segments ten and eleven on each side bearing a subdorsal and a stigmatal bristle; twelfth segment destitute of bristles; the long bristles described above are slightly longer than the transverse diameter of the body, and curved upward; there are also several much shorter curved bristles thinly scattered over the body, and they likewise occur on the head and legs; on the under side of each femur are two long bristles; each tarsus bears four rather long, knobbed bristles, resembling the digitules on the tarsi of certain kinds of Coccids. Towards the end of this stage the body becomes thinly covered over with a very short, white, woolly substance.

Duration of this stage, five days.

Second stage.—Same as the first, with these exceptions: First segment bearing twelve long bristles, of which four are in a row along each side of this segment, one is located slightly above the second bristle in each of these rows counting from behind, besides a subdorsal bristle each side, situated near the middle of this segment; segments three to seven each bear a transverse pair of bristles each side; the longest bristles scarcely exceed the transverse diameter of the body.

Duration of this stage, three days.

Third stage.—Body, blood-red, the subdorsal region being the darkest, but there are no definite black markings; first segment bearing fourteen bristles, six of which are in a row on each side of the segment, and one is situated above the second bristle in each of these rows, counting from behind; segments two and three each bearing a stigmatal cluster of four bristles each side and with a single bristle in front of each of these clusters; segments four to nine each bearing a stigmatal cluster of four bristles each side; segment ten bears a subdorsal bristle besides the stigmatal cluster of four bristles each side; segment eleven bears a subdorsal bristle and a stigmatal cluster of three bristles each side; segment twelve bears a transverse row of four rather short bristles; each of the clusters of bristles above described issues from a large elongated tubercle the apex of which is rounded and blackish; the bristles in these clusters are arranged one in front, another behind, and with a transverse pair between them, but on the eleventh segment the anterior bristle is wanting; these bristles are of unequal lengths, the transverse pair being longer than the others, these but slightly exceeding one-half of the transverse diameter of the body; head slightly darker than the body and marked with a black spot on each side; legs red, the tarsi slightly blackish; the surface of the body is thinly covered with a very short, white, crinkled, woolly substance which does not entirely conceal the ground color.

Duration of this stage, three days.

Fourth stage.—Same as the third stage, with these exceptions: Body marked each side by a subdorsal black stripe which passes between two rows of low, transversely oval warts which are blackish at their apices, two warts to each segment, except on the second and third segments, where only the lower wart is present, but neither the warts nor the black stripes extend upon the first segment; this segment bears eighteen bristles, of which seven are arranged in a row along each side of the segment, and one is situated above the first and second bristles in each of these rows, counting from behind; the eleventh segment bears a stigmatal cluster of four bristles each side; the remaining bristles are arranged as in the preceding stage.

Duration of this stage, ten days.

Pupa.—Orange-red, first segment marked with a medio-dorsal black spot, second and third segments each with a large transverse black spot; segments six, seven, and eight each with a transverse black spot on its anterior end, that on the sixth sometimes divided medially into two spots; surface thinly covered with a short, light yellow, mostly recumbent pubescence, which converges towards the middle of the dorsum, forming a small cluster near the center of each segment; length, 4mm.

Duration of this stage, fourteen days.

About three days before pupation takes place, the full-grown larva attaches itself to some object by the posterior part of the body, and in pupating the old larval skin is rent from the head to the anterior end of the seventh segment, and is allowed to remain, partially enveloping the pupa. About ten days after pupation takes place the pupa-skin is rent, disclosing the included beetle, but the latter does not issue from the pupa-case until four days after this stage is reached.

This ladybird breeds as readily in confinement as does the *Vedalia cardinalis* and closely resembles the latter in all of its stages. The obser-

vations above recorded were made during the months of August and September, and the insects were kept in glass jars in a sunny window of my office. The eggs are darker and much rougher than those of the Icerya, which they otherwise closely resemble, and are usually thrust into the egg sac of the latter. The young larvæ prefer the eggs of the Icerya to the insects themselves as food, and shortly after issuing from the eggs they burrow into an egg sac and frequently remain in it until full grown. On several different occasions I have reared a Novius larva from the egg to the adult state upon the eggs in a single egg mass of the Icerya. They spend a somewhat longer time in their preparatory stages than the Vedalia does, this being especially noticeable in the pupa stage; and being much smaller insects they do not destroy the Iceryas as rapidly as the Vedalia does. The latter appears to prefer the Novius larvæ to the Iceryas for food, and whenever the larvæ of these two ladybirds inhabit the same plant the Novius larva falls a prey to its more powerful rival. I learn from Mr. John Scott, the Horticultural Commissioner of Los Angeles county, that he introduced a few Vedalia larvæ into a glass jar containing a colony of the Novius, and, although he kept them well supplied with Iceryas for food, still in a short time the Vedalias had completely annihilated the Novius larvæ.

LEIS CONFORMIS.—*Egg.*—Elongate-ovate, twice as long as broad, the outline quite regular, tapering gradually toward each end, the upper end convex, the lower one flattened at its attachment; surface highly polished, but under a highly magnifying power appearing somewhat scabrous, owing to minute, blisterlike, raised spots which are thinly scattered over its surface; color, light lemon-yellow; length, $1\frac{1}{4}^{mm}$.

The eggs are attached by one end to a leaf or other object and are deposited in clusters of from three to forty-one eggs each. Time from deposition to hatching, seven days.

Larva: First stage.—Body of the usual Coccinellid form, being widest in front and tapering quite rapidly posteriorly; olive-brown, varied with black, and bearing many black, somewhat conical tubercles, each tipped with a black style which at its apex is compressed laterally and is truncate or sometimes slightly emarginate; first segment somewhat flattened above and bearing a circle of twenty-six tubercles; of these, the anterior fourteen (seven on each side) are arranged in a single row, and the style at the apex of each is longer than the tubercle itself; next to these are four transverse pairs of tubercles, two pairs on each side of the segment, the two tubercles composing the second pair being united at their bases; following these are four tubercles two on each side, in which, as also in the tubercles, comprising the four pairs above mentioned, the style is shorter than the tubercle itself: besides this circle of tubercles, there is also a transverse pair near the center of this segment; second segment, on each side, bearing a subdorsal oblique pair of tubercles which are united at their bases, a suprastigmatal cluster of five tubercles, three of which are united at their bases, the other two being slightly above and on either side of them; below this cluster is a single tubercle in front of which is a stout bristle; third segment the same as the second except that the suprastigmatal cluster contains only four tubercles, the anterior of the two single ones being absent; fourth segment, on each side, bearing a subdorsal cluster of three tubercles united at their bases, a suprastigmatal pair of tubercles which are also united at their bases, and below them is a single tubercle; segments five to eleven are the same as the fourth;

each of the tubercles on segments two to eleven is longer than the style at its apex; twelfth segment on each side bearing two subdorsal and two small stigmatal, widely separated tubercles, each of which is shorter than the style at its apex; head polished black and bearing a few stout bristles; legs black and also bearing a few stout bristles.

Duration of this stage, three days.

Second stage.—Same as the first, except that the color of the body is black and the tubercles on the seventh segment are yellow; the styles of the tubercles are not compressed at their tips; the united bases of the tubercles which are arranged in pairs or in threes are longer than the tubercles proper and each bears a few slender lateral bristles; the posterior tubercle in each cluster of three is longer than either of the others in the same cluster.

Duration of this stage, three days.

Third stage.—Same as the second, except that sometimes, but not always, some or all of the tubercles on the fourth segment are yellow.

Duration of this stage, three days.

Fourth stage.—There is no appreciable difference between this and the preceding stage.

This is as far as I was able to carry these larvæ, a host of mites belonging to the species *Heteropus ventricosus*, of Newport having invaded my breeding cages and in a very short time destroyed not only these larvæ, but also many others which I was rearing at the same time, the soft, recently transformed chrysalides and pupæ being attacked as well as the smaller larvæ of all descriptions. No specimens of the Leis were received by me after the above date, so I was unable to procure a fresh colony of larvæ and thus complete the life history.

On the 14th of May I placed in one of my breeding cages about a dozen adult specimens of *Leis conformis* and supplied them with orange twigs infested with an undetermined species of Aphis. Three days later some of the beetles were paired, and on the 19th of May I examined the twigs in this cage, but found no eggs; I then replenished it with fresh twigs infested with the Aphides, and in the afternoon of the same day this cage contained two clusters of eggs, containing seven and ten eggs, respectively. The beetles were very lively and fed greedily upon the Aphides. The females laid eggs readily in confinement, even when inclosed in a small-sized box. The larvæ were comparatively easy to rear and fed readily upon the Aphides, large numbers of which were destroyed in a day by a single larva.

Undetermined Coccinellid, (elytra yellow, marked with six black spots).—*Egg.*—Elongate-ellipsoidal, two and a half times as long as broad, light lemon-yellow, the upper end marked with a rather large white spot, surface highly polished, but under a high magnifying power appearing slightly scabrous, owing to minute blister-like spots, which are scattered over its surface; length, $1\frac{1}{4}^{mm}$.

Placed on end in clusters of about ten eggs each. Time from deposition to hatching, five days.

Larva: First stage.—Body of the usual Coccinellid form, olive-brown varied with black, sides of the fourth segment lighter, almost white; first segment bearing a circle of twenty-six elongated tubercles, besides a transverse pair near the center

of the dorsum; second segment, on each side, bearing a subdorsal cluster of three tubercles, a suprastigmatal cluster of five, below which is a pair of tubercles, and there is also a single tubercle situated between the subdorsal and suprastigmatal clusters; third segment on each side bearing a subdorsal and a suprastigmatal cluster of three tubercles, while between these two clusters, and also below the lowest one, is a pair of tubercles; fourth segment, on each side, bearing a subdorsal and a suprastigmatal cluster of three tubercles, and below the latter is a pair of tubercles, the anterior of which is smaller than the posterior one; segments five to eleven are the same as the fourth; all of the tubercles above described are black; twelfth segment, on each side, bearing a pair of subdorsal and a widely separated pair of stigmatal bristles; head polished black.

I was unable to carry these larvæ any further, owing to the invasion of the mites above referred to. Two of the beetles were destroyed by internal parasites, as already stated on a previous page of this report; the remaining beetles died without depositing eggs, and as no more specimens of this insect were received from Australia subsequently, I was unable to obtain any more eggs of this species and thus complete its life history.

The beetles were received at the same time as the *Leis conformis* above described, and were treated in the same manner as the latter. They were not as lively as these and did not deposit eggs so readily in confinement. Both the adults as well as the larvæ fed greedily upon the Aphides which I introduced into their breeding cages.

THALPOCHARES COCCIPHAGA.—*Egg.*—Turnip-shaped, being twice as broad as high, attached at one end, the upper end rather deeply concave and furnished with a small rounded tubercle in the center; surface covered with irregular raised lines which encircle the egg, besides others which extend vertically, these lines forming shallow cells of various shapes and sizes; diameter, nearly $\frac{1}{4}^{mm}$. Deposited singly.

Larva.—First stage.—Body whitish; head grayish-black; cervical shield dark gray; provided with six thoracic, four abdominal, and two anal legs, the abdominal legs located on the eighth and ninth segments; these as well as the anal prolegs are extremely short, but are encircled with minute hooks at their tips.

Full-grown larva.—Body very robust, dull white, usually with a tinge of yellow or pink; piliferous spots indistinct, pale brown; spiracles yellowish; head and cervical shield blackish-brown; no anal plate; legs as in the first stage; length, 8^{mm}.

Chrysalis.—Of the usual form, light yellowish-brown; destitute of transverse rows of teeth-like processes; posterior end rounded and bearing a transverse, slightly curved row of six rather short, recurved spines.

Shortly after issuing from the egg the larva spins around its body an oval case of light gray silk, which it drags around after it when crawling about in search of food. This consists of the younger specimens of *Lecanium oleæ*, and perhaps also the young of other kinds of Coccids. As the larva increases in size it enlarges its case by the addition of new material, and it frequently attaches to the outside of its case fragments of the scales, besides various other small objects, these being so small in size as to be scarcely noticeable except upon a close inspection. The case is closed at one end, while at the opposite end is a somewhat square opening, out of which the larva protrudes its head and the fore part of the body when feeding or when moving about upon the tree. Each of the four sides of this opening is furnished with a rounded silken

lobe, or prolongation of the case, and these lobes converge toward the center of the opening, thus closing the latter when the larva retreats into its case. After each meal the larva fastens its case to the bark by a few silken threads, then retreats into its case and remains hidden from view until the pangs of hunger again force it to come out in search of food. The chrysalis stage is passed within the silken case, and frequently ten or a dozen of the cases are fastened together in a mass by their occupants a short time before the latter assume the chrysalis form.

It is quite impossible to extract one of these larvæ from its silken case without fatally injuring the larva, so firmly does it retain its hold upon the inside of the case by means of the small hooks with which the prolegs are provided, and nothing short of cutting open the case will accomplish the removal of the larva. When removed from its case and placed upon a flat surface the larva is able to move about, but only very slowly, and in walking the posterior end of the body is elevated, no use being made of the last pair of prolegs. Whenever two of the larvæ thus removed from their cases meet each other a fight is almost certain to occur, each larva seeking to grasp with its mandibles the mouth parts of the other, and, if successful, it will frequently shake from side to side the head and fore part of the body of its opponent, somewhat as a terrier shakes a rat. In these encounters the softer parts of the body are never attacked, and the encounters are apparently in the nature of sport. The moths, as might be expected, are nocturnal in their habits, remaining perfectly quiet during the daytime and coming forth rather early in the evening.

My notes on this species are necessarily imperfect, as but few of the larvæ were obtained from eggs laid in confinement, and in order to work up their complete life history it would be necessary to frequently remove the larvæ from their cases, and this I was unwilling to do until the species becomes firmly established in this State.

At the present writing two of the most important of the imported species, the *Orcus australasiæ* and *Orcus chalybeus*, are breeding in two localities in this city, as well as in an olive grove in Santa Barbara County, and the former species is also breeding in Alameda County. While they do not increase with sufficient rapidity to give us the assurance that they will be able to practically free all of the trees in this State of the different kinds of scale insects that infest them, still they will undoubtedly prove valuable allies in keeping these scale insects in check.

Novius kœbelei is also firmly established here. I have it breeding in my office at the present writing, and have sent a few colonies to different localities in the State. The horticultural commissioner of this county, Mr. John Scott, also has colonies of this insect breeding in his office, and has sent out colonies in place of the *Vedalia cardinalis.* While this last-named insect has effectually kept in check the destruc-

tive Fluted or Cottony-cushion Scale (*Icerya purchasi*), still of course there is abundant room for this second species to aid in this commendable work. Being much smaller than the Vedalia and not passing through its changes any more rapidly, it is very doubtful whether the Novius could have accomplished the same work in the same time that the Vedalia did in California.

It is very probable that four other kinds of beneficial insects, the *Leis conformis*, *Alesia fromata*, the reddish-yellow ladybird with six elytral black spots, and the small black one with two large elytral red spots, are also established here, but these were received in such small numbers that some little time must elapse before they will have multiplied sufficiently to be met with except after a long and careful search for them. It is also possible that the Cryptolæmus and two or three species of Scymnids, as well as the Thalpochares, may yet be found to have gained a foothold here, but this can be determined only after the lapse of several months, or perhaps even longer than this. I have already alluded to the fact that the *Scymnus lophanthæ* was also among the specimens introduced, but this can hardly be considered an introduction in the same light as the other species, since it was already established here before these later specimens were received.

I have not observed that either of the two species of fungi received from Australia, the one attacking *Lecanium oleæ*, the other on *Aspidiotus aurantii*, has spread to the healthy scale insects, but of course it is possible that the spores of these fungi may remain dormant until the wet season sets in.

THE WALNUT SPAN-WORM.

The English Walnut is quite extensively grown in certain localities in this State, and, in proportion to the amount of care bestowed upon it, yields a larger revenue than almost any other tree grown upon this coast. It is remarkably free from the attacks of insects, those heretofore known to attack it never occurring in sufficient numbers to cause any widespread destruction of the trees or nuts. Two years ago, however, a span-worm appeared in such large numbers in a certain locality that many trees were almost completely defoliated by it.

The first intimation I received in regard to the appearance of this new pest was a letter from Hon. Ellwood Cooper, of Santa Barbara, under date of April 29, 1890, and which reads as follows:

> I send you by this mail a box of worms. Please write me by return mail what they are, whether from a moth, miller, butterfly, or beetle. What kind of eggs, and the time required for them to hatch? When do the worms go into the pupa state, and where? Nothing of this kind has ever been seen on the ranch before. My foreman said he saw the very small worms about ten days ago. I had never seen anything on the walnut trees, and hence did not at once go to look after them. A few days later I made an examination, but could find no eggs, yet very minute worms. I sent the foreman, but none could be found. The eggs must have been laid on the twigs, because the leaves have only been out about fourteen days. About one week

ago there were but few signs, now the whole thing is being eaten up. I never saw anything so ravenous. Please write me at once what to do and what it is. I fear the crop is gone.—ELLWOOD COOPER.

Thinking the matter of sufficient importance to require investigating, I paid a visit to Mr. Cooper soon after the middle of May. Prior to this, however, the trees had been sprayed with Paris green and water at the rate of 1 pound of Paris green to 130 gallons of water, and now it was no easy matter to find any living, healthy worms. The trees attacked were very large ones, being about 30 feet high, and the branches extending a distance of nearly 20 feet, making for the tops of the trees a diameter approximating 40 feet. The span-worms appeared upon nearly every tree in a grove containing 20 acres, but they were most abundant near the center of the grove, where they had almost completely defoliated the trees. They also appeared upon the walnut trees in an adjacent grove, but not in such large numbers as in the one above mentioned. Mr. Cooper informed me that he has lived on this ranch continuously for nineteen years, but never before had these or any other kind of span-worms appeared upon his trees in sufficient numbers to attract attention, and he is unable to account for the present invasion.

The following year these span-worms were also present upon some of the trees, but were far less numerous than during the preceding year. The infested trees were again sprayed with Paris green and water at the rate of 1 pound to 180 gallons, and this effectually destroyed the span-worms. In the month of March of the present year, however, Mr. Cooper wrote me that the span-worms were again appearing in large numbers and requested me to come to his ranch and investigate them. Having received instructions from Dr. Riley to this effect, I again, on the 6th of April, visited Mr. Cooper, and found that, while the span-worms were quite abundant upon some of the trees, still they were in much smaller numbers than during the season of 1890. I also made a careful examination of the trees growing near the walnut trees; these consisted of Olive, Persimmon, Eucalyptus, Sycamore, Alder, Oak, Elder, Willow, and a few other kinds of trees, besides various kinds of shrubs and plants, but failed to find specimens of this span-worm upon any of them, with the single exception of the Oak (*Quercus agrifolia*). The new, spring growth was just starting out upon this tree, and I found several of these span-worms feeding upon the newly expanded oak leaves; a careful comparison of these oak-feeding specimens with those from the walnut trees failed to disclose the slightest difference, and when I tested them with walnut leaves they also fed readily upon them. Several trees of black walnuts are also growing on Mr. Cooper's ranch, but these were not yet in leaf at the time of my visit.

During a visit which I made, in the latter part of April, to portions of Alameda and Santa Clara counties I found specimens of this same

kind of span-worm on some apple and prune trees as well as on English walnuts in some of the orchards of the above-mentioned counties. Under date of April 27, 1892, Mr. Cooper writes me that he recently found this pest in three other groves of English walnut in Santa Barbara County, where it was very destructive to the leaves of these trees. Thus it appears that already this span-worm is quite widely distributed over the State, and unless active measures are adopted to suppress it there is every probability that it will in time very seriously interfere with the profitable growing of English walnuts upon this coast. Unfortunately, the moths have not yet issued, so it is impossible at the present writing to identify the species or to ascertain if it has proved destructive in other States than our own.

The eggs from which these span-worms hatch are flattened oval, as if compressed between the thumb and finger; the surface is quite scabrous, and bears numerous minute transverse ridges; at each end of the egg are numerous quite large, shallow punctures; the color is a dark greyish drab, with a strong brassy tinge; length, about $\frac{5}{6}$ mm.

These eggs are fastened to the small twigs of trees, in loose, irregular patches, each egg lying on one of its flattened sides; there is no regularity in their arrangement upon the bark of the twig. One piece of a twig an inch and a half long by a quarter of an inch in diameter contains upwards of two hundred of these eggs. The young span-worm issues through a nearly circular hole in the larger end of the egg, and the empty eggshell is of an iridescent, pearly white color.

The full-grown span-worm closely resembles the larva of the Eastern *Angerona crocataria* as figured on Pl. VIII, Fig. 6, of Packard's "Guide to the Study of Insects," but the piliferous spots are larger, giving to the body a much rougher appearance, and when viewed from the side there is seen to be a large prominence on the dorsum of the fourth and sixth segments as well as on the fifth and eleventh. I give herewith a detailed description of this span-worm, in order that it may be recognized in the future:

Body of nearly an equal thickness throughout its length, the head and first thoracic segment slightly wider than the rest of the body; head as seen from front a trifle wider than high, the lobes rounded and destitute of a tubercle or other process; color of head dark brown, variegated with yellowish; body light pinkish gray varied with darker gray or purplish, or sometimes with black and yellow, never marked with distinct lines; piliferous spots tuberculiform, black, or dark brown, and back of each of the spiracles situated on the fifth and sixth segments is a large, conical, fleshy prominence surmounted by a piliferous spot, and on the dorsum of each of the segments four, five, six, and eleven, is a pair of similar but smaller prominences; in front of the pair of prominences on the dorsum of the eleventh segment is a pair of spots which are of a clearer yellow or gray than the ground color, each spot usually bordered each side by a short black line; spiracles orange-yellow, ringed with black and usually situated on a yellow spot; venter concolorous with the upper side, marked in the middle with a faint whitish stripe, and with a less distinct one near each outer edge; ten legs; length, 20 mm.

These span-worms reach their full growth in May and then enter the earth to a depth of from two to four inches; here each one forms a smooth cell, but does not spin a cocoon. The chrysalis state is assumed a few days after the cell is completed, but the moth does not issue until the following winter or early spring. The chrysalis is of the usual form, of a dark reddish brown color, and the posterior extremity bears two diverging spines; the tips of the wing-cases almost reach the posterior end of the fifth abdominal segment; length, 14^{mm}.

Perhaps the most important enemies of these span-worms are certain kinds of insectivorous birds, particularly the black birds, which I repeatedly observed in the infested trees, and Mr. Cooper informs me that he has seen one of these birds carrying four of the span-worms in its beak. Of internal parasites, only one species is at present known to me to attack these span-worms; this is a small black, four-winged fly belonging to the genus Apanteles. The sides of its abdomen are largely yellow, the front and middle legs, including their coxæ, are also yellow, while the hind legs, with the exception of the tips of the femora and tibiæ, and the whole of the tarsi, are of the same color. I found several of the white cocoons of this parasite attached to the trunks of the infested trees on the 21st of May, and near each was the shrunken remains of one of the span-worms in which the parasite had lived. One of the parasitic flies issued one week later. It is probable that a Tachina-fly of some kind also attacks these span-worms; on the day above mentioned I found one of them to whose body was attached a white egg, evidently of one of these flies, but as no parasite issued from this span-worm I am unable to settle this point at the present time.

Mr. Cooper informs me that he sprayed some of the infested trees with Buhach and water at the rate of 1 pound to 50 gallons, but this did not destroy the span-worms. He also tried the kerosene emulsion, such as he uses for the destruction of the Black Scale (*Lecanium oleæ*) on olive trees, but this was not effectual. Paris green was also used in varying strengths, from 1 pound in 50 gallons to 1 pound in 200 gallons of water, and this latter strength he found effectually destroyed the span-worms without injuring the trees. With each 100 gallons of this mixture he used 20 pounds of a soap made principally of mutton tallow and caustic soda; this caused the solution to spread more readily over the leaves, and also had a tendency to cause the poison to adhere more firmly. The soap was first dissolved in hot water, after which the Paris green was added, then the balance of the water, and the solution was kept constantly stirred while being applied to the trees. Mr. Cooper informs me that five men—one to drive the team, one to stir the solution in the spraying tank, another to pump, and two to handle the spraying nozzles—sprayed on an average 27 of his largest walnut trees in a day; this is equivalent to one acre of trees per day.

THE CODLING MOTH.

(*Carpocapsa pomonella* Linn.)

It is not my purpose to give a complete account of this insect at the present time; its habits and life history are pretty well known to those of our fruit growers who suffer by reason of the inroads it makes in their deciduous fruit crops. A very full account of this pest, written by Mr. L. O. Howard, will be found in the Annual Report of the U. S. Department of Agriculture for the year 1887 (pp. 88–115). I will therefore simply record a few additional notes which have come under my observation during the last eight or nine years.

In the above-mentioned account it is stated that in the northern part of this country the Codling Moth is two-brooded, while in the south it is three-brooded. My notes indicate that in California, as might be expected, it is also three-brooded, the moths from the hibernating worms issuing in the latter part of March and during the first half of April, those of the next brood appearing in June and during the first half of July, while the third brood of moths appear in August and the early part of September.

Of the two kinds of internal parasites reported as preying upon the larvæ and pupæ of the Codling Moth in this country, the *Pimpla annulipes* is not represented in my collection from California. The second species, *Macrocentrus delicatus*, not heretofore known to occur upon this coast, I have never bred from the larvæ of the Codling moth; but my notes indicate that on the 3d of September, 1891, I bred three specimens of this parasite from larvæ of a Tortricid, *Pædisca strenuana* Walker, which lives in the dry stems of a wild sunflower, *Helianthus annuus*. I notice that in volume III of INSECT LIFE (p. 59), the editors record having bred this parasite from another Tortricid, the *Cacœcia fervidana*, as well as from one of the Dagger-moths, *Acronycta oblinita*, making in all four different insects upon which it is known to prey.

In the above-mentioned account it is stated that the Dermestid beetles, *Trogoderma tarsale* and *Perimegatoma variegatum*, are reported as preying upon the pupæ of the Codling Moth in California. My observations on the larvæ of these two beetles lead to the belief that the Trogoderma larva feeds upon dead insects, but will not attack the living ones; on the other hand, while the Perimegatoma larva doubtless prefers dead insects upon which to feed, yet it will also feed upon the smaller living pupæ, or chrysalides, of moths; and perhaps also those of other insects.

This latter larva bears quite a close resemblance to the one figured at 396, on page 448, of Packard's "Guide to the Study of Insects." It is of a dark-brown color, with the sutures of the segments whitish; the body is quite hard, somewhat flattened, of nearly an equal width throughout, except that the last fourth tapers slightly posteriorly, and the body is a trifle widest at the fourth segment; there are appa-

rently only eleven segments, the first of which is the longest, and is nearly as long as wide; the last segment is rounded behind, and is destitute of a projection of any kind; the body is thinly clothed, with rather long yellowish and dark-brown hairs, and in the older individuals each of the last three or four segments bears a transverse pair of short, brush-like tufts of black hair, which are wanting in the younger individuals; the head is nearly as wide as the first segment of the body, is of a reddish brown color, and is thinly covered with rather long reddish hairs. This larva attains a length of about 6^{mm}, and the pupa is formed within the old larval skin, the latter simply splitting open along the back. The larvæ are found during the greater portion of the year, and are quite frequently met with among the dead leaves and other débris lying in the crotches of orange trees. I have bred the beetles in June and also in December.

On the 17th of July, 1890, I found a larva of this kind engaged in feeding upon a dead and dry moth. I also inclosed three of them in a box containing a dead and dry chrysalis of the moth *Tæniocampa rufula*, and in a few days they had devoured it. I then placed in their box a living chrysalis of this moth, but they did not harm it, and in due time it was changed to a moth. A fresh, living chrysalis of a Tineid moth which I placed in their box, however, did not fare so well; I saw one of the larvæ feeding upon it, and it was finally entirely consumed. I also placed in their box a living chrysalis of a Codling Moth still in its cocoon, and they finally gnawed a hole through the cocoon, entered, and devoured the chrysalis.

The fact above recorded, that one of these larvæ was found feeding upon a dead, dry moth, and the further fact that the larvæ devoured a dead dry chrysalis of a moth, but would not attack the living chrysalis of the same kind of moth, is sufficient evidence to prove that these larvæ prefer dead and dry insects to living ones. Still, the other cases here recorded indicate that under certain conditions they also attack the healthy living chrysalides.

The larva of the Trogoderma quite closely resembles that of the Perimegatoma above described, but is a much more robust form; the body is widest at the last third of its length, and is of a lighter, more yellowish color; the short brushes of hairs on the posterior portion of the body of the older individuals are also yellow instead of black. I have repeatedly found these larvæ within the empty cocoons of the Codling Moth, but there was nothing to indicate that they had entered the cocoons prior to the escape of the moths, and it is probable that they fed only upon the empty shell of the chrysalis and the cast-off skin of the larva. I placed a dead and dry Horse-fly in a box containing several of these larvæ, and they soon attacked it and in a comparatively short time reduced it to a powder. I then placed in their box a living larva and two living chrysalides of a Tineid moth, but they had not attacked either of them after a lapse of six weeks. This would seem to indicate

that these larvæ feed only upon dead insects, and that they never attack those still alive.

For the destruction of the Codling Moth our growers of deciduous fruits depend almost altogether upon spraying the young fruit with Paris green and water. The proportions vary from 1 pound of the Paris green in 160 gallons of water to 1 pound in 200 gallons. My own observations and experiments indicate that the former strength is liable to injure the leaves somewhat, so it will be advisable to use it not stronger than at the rate of 1 pound to 200 gallons of water.

On the 12th of May, 1890, I had twenty-two pear trees sprayed with Paris green and water at the rate of 1 pound in 160 gallons, and to this was added 4 gallons of the resin wash, composed of: resin, 20 pounds; caustic soda, 6 pounds; fish oil, 3 pints, and water sufficient to make 100 gallons. This was added for the purpose of causing the solution to spread more readily over the trees and fruit. These pear trees were kindly placed at my disposal by Mr. C. H. Richardson, of Pasadena. They averaged about 10 feet in height, and the tops measured about 4 feet in diameter. Twenty-eight gallons of this solution were used on these twenty-two trees. I examined them at intervals throughout the summer; the fruit had not been in the least injured by the solution, but a very few of the leaves had small brown spots burned in them, not sufficient, however, to produce any material injury. When ripe, fully five-sixths of the pears on these trees were free from the attacks of the larvæ of the Codling Moth, whereas on adjacent trees not treated nearly all of the fruit had been attacked by these larvæ.

Throughout the entire summer season these sprayed trees remained free from the attacks of the Pear-slug (*Eriocampa cerasi* Peck), although I found leaves on some of these trees in which the eggs of this insect had been deposited; and upon adjacent pear, apple, and quince trees that had not been sprayed these slugs were quite numerous. It would well repay our growers to spray their trees with the above-mentioned solution as a protection against the attacks of these slugs and other leaf-eating insects.

It is the custom of some of the growers in the northern part of the State to first dissolve the Paris green in ammonia before adding it to the water, but it is very doubtful that this is any improvement. Ammonia is known to be very injurious to vegetation whenever brought in contact with it. I am informed by Dr. H. W. Wiley, the chemist of this Department, that Paris green, which ordinarily consists of a mixture composed of one molecule of the acetate of copper and three molecules of the arsenite of copper, is changed to an entirely different chemical compound when treated with ammonia, this compound then consisting of the acetate and the arsenite of ammonia combined with an ammoniate of copper—a mixture much more soluble in water than Paris green is. It is evident that the more insoluble the Paris green is rendered the less liability there will be of its injuring the foliage of

trees sprayed with it, and there will be less danger of its being washed off of the trees by the rains. Instead, therefore, of seeking to render it more soluble, the opposite course should be pursued, and, if possible, the Paris green should be treated in such a manner as to render it wholly insoluble in water. To accomplish this result it is only necessary to mix a pound of freshly slaked lime with each pound of the Paris green, add a gallon or two of water, and let stand over night. Treated in this way, the portion of the Paris green that is soluble in water, and that produces the injury to the trees sprayed with it, unites with the lime to form a compound wholly insoluble in water; by this simple and inexpensive treatment the Paris green is rendered harmless to the tree, while at the same time its poisonous nature is not lessened to any appreciable extent. This process was first used by Prof. C. P. Gillette, now entomologist of the Colorado Experiment Station, and his observations have been confirmed by a number of other experimenters.

The great benefits resulting from treating fruit trees with Paris green for the destruction of the Codling Moth are well understood by the majority of our growers of deciduous fruits, a few of whom have learned this by bitter experience. At a recent meeting of the horticultural commissioners of southern California, Mr. John Scott, the commissioner for Los Angeles County, stated that early in the present season he instructed his inspector in a certain locality to serve a notice on all of the fruit growers in his district to spray their pear and apple trees with Paris green and water for the destruction of the Codling Moth. The majority of the growers complied with the request, but one of them, for some reason, asked to be allowed to defer the spraying for a short time, and his request was granted. The spraying, however, was deferred longer than was originally intended, and it was now considered too late in the season to obtain good results, so his trees were not sprayed. Long before his pears were ripe this grower made a contract with the manager of one of the canneries in this city whereby he was to deliver his crop of pears to the cannery, for which he was to receive the sum of $2,000. When, however, he delivered his first load of pears, so badly were they infested with the larvæ of the Codling Moth that the manager of the cannery refused to accept them. The grower then offered them at three-quarters of the original price, but his offer was refused; he next offered them for one-half of the price originally agreed upon, but the manager informed him that he would not accept the pears even if they were given to him free of all expense. By the outlay of a very small sum of money necessary for spraying the trees all of this loss to the grower might have been averted.

REPORT UPON INSECT INJURIES IN NEBRASKA DURING THE SUMMER OF 1892.

By LAWRENCE BRUNER, *Special Agent*.

LETTER OF SUBMITTAL.

LINCOLN, NEBR., Nov. 12, 1892.

SIR: As special field agent for Nebraska, I submit herewith a report upon insect injuries in this State during the summer of 1892. The report touches upon the outlook for destructive locusts, but is mainly devoted to a consideration of certain sugar-beet insects, with a brief notice of the miscellaneous injurious insects of the season.

Very respectfully yours,

LAWRENCE BRUNER.

C. V. RILEY,
U. S. Entomologist.

DESTRUCTIVE LOCUSTS.

On account of the great amount of injury done by destructive locusts during the past few years and because of their threatened increase again early the present season in many localities over the country at large, a careful watch has been maintained during the season that has just passed for reported injury to crops by these much-dreaded insects. It is with pleasure, therefore, that I am enabled to state that comparatively little damage has been done by them the country over. True, in a few localities, there was some local injury; but, when we take into consideration the fact that last year a number of different species were unusually numerous in various portions of the country, west, north, south, and east, it is certainly encouraging, to say the least, that so little injury has resulted the present year.

Here in Nebraska several species hatched in rather large numbers and began to do some injury to gardens; but during the summer these became more or less infested with parasites of different kinds. These parasites thinned their ranks materially. In a number of localities the fungous disease known as *Empusa grylli* killed off myriads of the

remaining individuals, while at the same time others became literally covered with the Locust Mite (*Trombidium locustarum*). In fact, so extensively were these insects beset with afflictions of one or another kind that but few eggs were deposited. Even where they were, the large number of the egg parasites present will likely insure comparative immunity from locust attack next year.

From the northward we have heard but little of the pest that at one time last year appeared to be becoming so formidable. In central Idaho and portions of Utah and Nevada, where several species did considerable damage to both crops and grasses on the range, comparatively little injury has been reported, while from Colorado, western Kansas, and southwestward, the pest seems to have dwindled to nearly the normal condition for the region. Even in portions of Indiana, Ohio, and other sections of the East, where last year these insects did some injury, the conditions have somewhat improved.

CAUSES FOR THIS DECREASE IN THEIR NUMBERS.

It is not at all surprising that these insects have so suddenly become less numerous in the many localities where they were so recently threatening devastation. The large number of parasites and predaceous insects which attack them have had an opportunity to increase also. These latter, together with the Entomophthora, which has been unusually abundant and severe during the past few years, have combined in reducing the pest. Here in the city of Lincoln and environments this year the dead bodies of *Melanoplus differentialis* were to be seen by the thousands clinging to weeds, stems of grasses, and other vegetation, where they were overtaken by death from the effects of the disease. On some single weeds more than a dozen of the hoppers were frequently to be seen. The dead bodies of other species like the *femur-rubrum*, *bivittatus* and *atlanis* were also occasionally to be met with upon the same weeds. These latter were, however, much less common.

One feature observed in connection with the distribution of locusts of this region was the presence in many parts of middle and eastern Nebraska of such species as *Dissosteira longipennis* and *Melanoplus spretus*, which must have come from abroad. Here at Lincoln both of these species were of quite common occurrence. On the university campus a female of the former was taken *in coitu* with a male of *Dissosteira carolina*. Other specimens of the same species were taken at Norfolk, Grand Island, West Point, and Columbus, and even in the vicinity of Hot Springs, S. Dak.

Such species as *Camnula pellucida* and the glaucous-legged form of *M. atlanis*, that have been mentioned on former occasions as gradually moving eastward and southward, were this year met with in rather large numbers in different parts of the Black Hills and even in the northwestern counties of Nebraska.

BEET INSECTS.

Possibly more attention was paid during the summer to sugar-beet enemies than to any other class of insect pests in the region watched by me. This was due to the interest which is centered in that particular crop at the present time and also because of my having already paid considerable attention to this subject. It is needless, therefore, for me to state that during the season several additional species have been found attacking that plant here in Nebraska. Among these a small Hemipteron (*Hadronema militaris* Uhl.), that has heretofore been frequently seen and taken on different species of Amarantus in the western.part of the state and in Colorado, was very common, in fact quite numerous, upon a small patch of beets in Sioux county during the latter part of July. Like others of these Hemiptera it attacks the leaves and leaf stems by inserting its beak and sucking the sap. Usually, but not always, the points attacked show as stained or partially deadened spots. Two or three additional leaf-hoppers were also taken upon beets here and at Norfolk, West Point, Grand Island and other locaties where beet fields were visited. These, however, were not present in sufficient numbers to do any noticeable injury to the parts attacked. The names of these were not ascertained, but will be reported later if deemed advisable.

Blister-beetles of several species, though none that were new to the plant, were unusually common and troublesome at a number of localities within this State and parts of Kansas during the season. Here at Lincoln, as well as at other localities, the common black one, *Epicauta pennsylvanica*, was exceedingly annoying to the owners of patches of beets. This beetle always comes and goes in comparatively large numbers, and one never knows where it will settle in the field. Choosing certain plants the insects congregate upon them and either eat the leaves full of holes or completely strip off all the foliage before going to the adjoining plants. Or, possibly, as soon as one plant has been stripped, they will go to another part of the patch or else leave altogether. In Sioux county the small Spotted Blister-beetle, *Epicauta maculata*, appeared to be the most common of these insects, and was always met with in large numbers on upland wherever beets were growing or a clump of the *Chenopodium album* occurred. Others of the blister-beetles were taken in the beet fields during the season, but these were present in much smaller numbers, and did but little damage as compared with what was done by the two species named above. Hand picking was more successfully used in combating these insects than any other remedy tried. Poisons in the case of *Epicauta pennsylvanica* proved to be of little or no value, since the insects often left immediately after the application was made, and at all times before they had eaten sufficient of the poisoned leaves to have any visible effect upon them. In the case of the Spotted Blister-beetle, poison was not tried that I am aware of; but I believe it would be more effective

against it than against *pennsylvanica*, for the former is less easily disturbed when feeding, besides being more regular in its habits than the latter. Like that species it is exceedingly gregarious in its nature, and always occurs in immense numbers when found at all.

Some indications were found at West Point of the possible injury that can be inflicted upon the beet crop by White Grubs. Here on one small field it was found that fully 15 per cent of the beets had been killed or injured by some insect working under ground. An investigation soon showed the criminal to be the grubs of some one or more species of *Lachnosterna*. These grubs had eaten away the tap-root and all the fine fibrous roots at a distance varying from 6 to 8 or 9 inches below the surface, but averaging about 7 inches. A dry spell coming on the tops began wilting, and finally died, after which the roots rotted in the ground. In this case the ground had been idle a year or more. This would suggest to us the advisability of not using grass land for beets; but to plant in ground that has been thoroughly cultivated for two or more years prior to its use for beets.

The Beet Web-worm.—Preëminent among the insects that attacked the beet crop here in Nebraska during the season which is just coming to a close, were two or more species of web-worms belonging to the genus *Loxostege* as at present restricted. Of these the one known as *Loxostege sticticalis* has been the chief depredator. Its history as an injurious species can be given briefly, as follows: By investigations instituted here at the experiment station only after the injury had mostly occurred it was ascertained that last year it was noticed that beets growing in the vicinity of Grand Island, Norfolk, and some of the adjoining towns, which supplied the beets for the two factories in the state, were infested by a few of the worms. These, however, did not appear in sufficient numbers to cause alarm at the time, or even to suggest to the interested parties the advisability of learning something of their nature, life history, and possible remedies. This year the caterpillars again made their appearance in these same localities and also at the Government station located at Schuyler. Considerable injury was done at this last-named locality on the experimental plats of sugar beets by a brood of the worms that matured late in July. Whether or not this was the first brood that appeared during the season is not positively known; but that it was the first brood that did visible injury is quite evident. Had this been otherwise the notice of Mr. Maxwell would have been called to them earlier in the season. As soon as the insect was observed by him to threaten the beets in his charge, as I am informed, specimens were at once sent to you in Washington. He also told me that experiments were at once started with a view to controlling the pest. Just what was accomplished in that direction I was unable to learn at the time of my visit to Schuyler on the last of August when the next brood was at its worst, but I presume he has reported to the Department just what was accomplished in this direction.

We did not have the insect here at Lincoln in sufficient numbers to attract attention. Although several larvæ of the ordinary Garden Web-worm (*Loxostege similalis*) had been taken early in July, nothing was thought of the matter and no further considerations taken concerning them until after the destructive brood had done its work at Grand Island and Schuyler, and a report of its presence and injuries was seen in the state papers. A special inspection of our beet plats at this time resulted in the finding of a number of specimens of another web-worm that we had noticed on several former occasions working on Amarantus and Chenopodium, but not on the beet. Upon visiting the station at Schuyler it was found that this second web-worm was identical with the one which occurred there; and, as Dr. Maxwell assured me, the same as was then present at Grand Island and several others of the surrounding towns where beets were being grown. A couple days later the same insect was found to be quite plentiful at Norfolk, Platte Center, and Genoa, where many of the beet fields either had been stripped or were at the time being stripped of their leaves. At Norfolk the greater part of half a day was spent in company with Mr. Huxman, the agriculturist in charge of the fields which supply that factory. Here a careful examination of the grounds was made and some facts gathered in relation to the insect as it appeared in this locality at least. Several new insects were here added to the list of "beet insects" as heretofore recorded. Afterward Norfolk, Stanton, Wisner, Beemer, and West Point were visited. At each of these localities sugar beets had been planted for the Norfolk factory, and at each some signs of the insect in question were found, though in much smaller numbers than where beets had been grown the year before.

From observations made at these different localities, and from information gathered through conversations held with various persons who were interested in the culture of beets, the following facts were gathered: These web-worms are more numerous away from sheltered localities than near bordering groves; and on high grounds, as hill tops and slopes, than on low flat grounds; they are never plentiful on a piece of ground planted to beets for the first time unless it adjoins one that was in this crop the year before; they are more plentiful in the middle of large fields than in small ones, and those that were allowed to run to "pig weeds" the preceding year, than in those where these weeds were kept down. The insects are also apparently more numerous where the soil is sandy than where it is heavier; at least this latter appeared to be the case in the localities where I made my observations. It was also learned that these web-worms are very subject to the attack of a number of parasitic insects, as well as falling prey to several species of predaceous beetles, bugs, and wasps, while birds and toads seem to relish them. Chief among the parasites reared from the specimens secured at Schuyler, Norfolk, and Grand Island is a small yellowish Hymenopterous fly. Next in point of numbers is a species of flesh-fly.

This latter was observed to be rather common in the fields both at Schuyler and Norfolk, while it has been bred in fairly large numbers from Grand Island worms. In addition to these, several other parasites have thus far been bred from the web-worms contained in my breeding cages.

As to the life history of these web-worms we are posted only in a general way, and not specifically. Our observations on the present species, *Loxostege sticticalis*, have not extended over a period of more than three months, hence we can not positively assert how it carries itself throughout the year. That it varies somewhat in its transformations and developments at different periods of the year is quite evident from what little we have seen of it so far. But two weeks is required between the maturity of the late July caterpillars and the appearance of the moths for the next brood. These immediately mate and deposit their eggs for another brood. The worms must therefore transform to chrysalids immediately after entering the ground. Such is not the case with the caterpillers of the last brood. With these the chrysalis stage is not entered for some time—possibly not until very late in the fall or even during the following spring. When I visited the Grand Island fields, fully three weeks after the last worms had entered the ground, they were found still in the caterpillar stage. Even at the present writing most of those in my breeding cages are unchanged. In this respect the insect imitates the slugs of some of our saw-flies. Its burrow is made and lined with silk, and the inner cocoon constructed immediately on entering the ground, but the worm instead of at once changing to the pupa stage lies in a semi-torpid condition until the proper time arrives for the change to take place, whether the insect enters the ground during the summer brood or broods when transforming, was not learned; but, if its life history is similar to that of the common Garden Web-worm, *Loxostege similalis*, it does not, but merely spin among the débris on top of the ground. Some of the larvæ of the August brood transformed and issued during September and October. It is barely possible that there is another set of caterpillars produced by these stragglers during the fall if the weather permits; but, as indicated above, the majority of the August brood remain unchanged until sometime during the following spring.

At least three distinct forms of these web-worms were taken from beet fields in different parts of the State, and a fourth one was found upon *Chenopodium album* growing in waste places here at Lincoln. Possibly still others might have been recognized if a close observation had been kept for that purpose. The similar food habits among the species of a genus of insects will very likely give us several more of these web-worms to add to our already large list of beet insects.

The web-worm found feeding on the *Chenopodium album* here at Lincoln can be recognized by the following description which was drawn up at the time of capture, and before it spun up: Length, 20^{mm}; slender,

tapering gently towards both ends. Of a light transparent green, the head and cervical shield inclining to amber yellow, but with a greenish tinge. Four small, whitish piliferous spots upon dorsum of segments—the anterior pair somewhat nearest together. Very fine hairs arising from these piliferous spots, as well as from sides. Larva very active—jumping aside and squirming vigorously when touched, as in the larvæ of Garden and Beet Web-worms. Also spins a slight web when feeding, to which it retreats when at rest.

Mamestra sp.—While walking through the beet fields at Norfolk a number of specimens of a Noctuid larva, apparently a Mamestra, were taken, in company with the web-worms mentioned above. This larva is about the size and has something of the same general appearance of the dark form of *M. chenopodii*, but differs from that insect in habits and markings. It was apparently quite plentiful, as specimens were taken at several different points in the fields, and three of them were found on a single row within 6 feet of one another. None of them were reared, as my breeding jar was overturned and the caterpillars destroyed by some one who meddled with affairs not belonging to his duties.

Anthomyia sp.—In connection with beet insects it might be well here to refer to a Dipterous larva that was taken here in Lincoln mining the leaves of *Chenopodium album*. Whether or not this is one of the species of Anthomyia which Lintner found mining the leaves of beet in New York, I can not say; but, from what I have observed heretofore in connection with these weed-feeding insects, there is danger of all of the enemies of the Chenopodaceous plants attacking the beet. Hence, whether this is a recorded enemy of the beet or not, it is very liable to become such sometime in the future. In its mode of attack this larva is somewhat peculiar, entering the leaf and feeding upon the pulp it soon separates the cuticles, making the leaves appear blistered. The maggot, in case of the Chenopodium, requires the substance of several leaves before coming to maturity, hence is obliged to pass from one leaf to another. These maggots are from 7 to 8^{mm} in length and nearly 2^{mm} in their greatest diameter. When ready to transform they enter the ground and there undergo their change to the pupa. One of the imagos issued within ten days of the time of entering the ground. The others, of which there were five, are still in the ground.

Silpha opaca.—During my visit at Norfolk and while talking with Mr. Huxman relative to Beet Insects in general, he mentioned the fact of the injury done by *Silpha opaca* in Germany. He said that the larva of this beetle was by all odds the most troublesome insect pest with which beet growers in that country had to deal. Hand picking was the remedy usually resorted to. He also stated that he had seen several specimens of the insect during the past summer at West Point, this State, upon sugar beets, and that he had killed them. He said that he could not be mistaken about the insect, as he had seen too

many of them in Europe not to know them at sight. With this second reported presence of this insect in beet fields at this one locality it begins to appear that perhaps, after all, it is present in America.

CHINCH-BUG NOTES.

While this insect has not been general over the State, it has begun to increase in such numbers in some of the counties along our southern boundary as to cause an uneasy feeling among the farmers of the section in question. Several letters have been received from different individuals in the counties of Nuckolls, Franklin, and Fillmore, asking for aid in the suppressing of this insect, which, as their letters stated, was becoming quite numerous and was threatening the fall wheat. They all asked for diseased bugs with which "to innoculate the healthy ones" in their respective neighborhoods. These letters were received during the latter part of September. Heavy rains have fallen in the region since, and nothing further concerning the bugs has been heard.

MISCELLANEOUS INSECTS.

Aside from the damage to beets by web-worms, the most marked injury done by insect pests in Nebraska during the season which has just come to a close was due to the presence of several species of caterpillars and saw-fly larvæ. Some of these have been excessively numerous in portions of the State, where they did great injury to the trees attacked. Some of these were the tent caterpillars, Fall Web-worm, the Walnut Datana, Cecropia larva, Green-striped Maple-worm, Tussock Moth, the Ash-tree Sphinx, *Cœlodasys unicornis*, and a species of Lyda (?) that worked upon the wild and tame plums. The Pear-tree Saw-fly also made its appearance within the State and did some injury to trees growing near Norfolk, in Madison County.

In towns and cities the caterpillar pest appears to be greatly on the increase, and it is next to impossible to impress upon the authorities the necessity for taking decisive steps toward their destruction. The comparative absence of insectivorous birds and of predaceous and parasitic insects is the cause for their increase. These latter are kept down by the burning of rubbish and other refuse under which they hide and spend their winters.

REPORT ON INSECTS OF THE SEASON IN IOWA.

By HERBERT OSBORN.

LETTER OF SUBMITTAL.

AMES, IOWA, *November 5, 1892.*

DEAR SIR: I inclose herewith a report on some of the observations for the year 1892, and beg to acknowledge at this time the many favors received which have been a material assistance in the prosecution of the year's work.

Very respectfully yours,

HERBERT OSBORN.

Dr. C. V. Riley,
U. S. Entomologist, Washington, D. C.

Perhaps the most striking features of the insect conditions the present year have been the almost total absence of many of the common pests during the early part of the season, a consequent slight amount of damage from insect attack, and the rapid multiplication of insects during the later months of the year and some quite conspicuous injuries. One of the most striking instances of this is to be noted in the plant-lice which were exceptionally rare during the spring and summer, but in late summer and autumn multiplied prodigiously and caused serious injuries to many kinds of plants.

The season was unusually backward and the spring months marked by much rain and cold weather, which retarded insect life in general.

Such reports as were received during the early part of the season indicated little if any damage even from such common pests as cutworms, squash beetles, etc.

The species of "bill-bugs" (Sphenophorus), which have been scarcely noticed in the State heretofore, have become plentiful, and one species, *Sphenophorus parvulus*, quite threatening in its attacks upon corn. This indicates naturally a considerable damage to grasses and probably wheat and other cereals, which passes without notice. It is quite probable that this species will demand serious attention from Iowa farmers during the next few years. *Sphenophorous ochreus* has attracted some

attention, but no serious damage has resulted from its presence so far as I know, and I do not anticipate from it any serious difficulties for this State. Attention has been called to these in a paper read before the Association of Economic Entomologists at Rochester and published in INSECT LIFE (vol. V, p. 111), and no further notice of them need be given here. Several cases of insects affecting grain in storage have come to my notice, and especially in the case of mill owners there seems to be a decided interest in the subject and a desire to adopt remedies for the insect pests that infest their mills. It is needless to add that the recommendation of bisulphide of carbon has given very satisfactory results.

The Potato Stalk Weevil (*Trichobaris trinotata* Say) has been quite plentiful and destructive, causing a loss of a large percentage of the crop on the college farm and probably over a considerable part of the State, though from the nature of its attack it seems to escape the notice of most growers.

A quite notable outbreak which came directly under observation was that of the Diamond-back Moth (*Plutella cruciferarum*) upon Rape, Cabbage, Cauliflower, and related plants. This insect has seldom caused any noticeable injury, though often observed as occurring in limited numbers, but this year it became so abundant as to seriously damage all the patches of Rape on the college grounds. The worms are so well protected in folds of the plant leaf and many of them on the under side that they are difficult to kill, and sprays of London purple were only partially successful, and it seemed that this poison applied in the form of powder diluted with flour and blown among the leaves was more effective.

The Cabbage Plusia (*Plusia brassicæ*) was also plentiful and accompanied the preceding species in their attacks on Rape, Cabbage, etc. For a time they caused more injury than that species. They were, however, attacked by a disease that swept many of them off, so that their damage was perhaps not so important in the aggregate as that of the preceding species.

The Imported Cabbage Butterfly (*Pieris rapæ*) was not seen at all in the early part of the season and it was thought that the *Apanteles glomeratus* mentioned in last season's report had accomplished a thorough work; but late in August and early in September butterflies appeared in large numbers and larvæ were fairly plentiful in some cabbage patches during October. Of course the scarcity during the fore part of the season may have been due to the previous abundance of parasites, but it shows that such parasitism does not furnish a permanent check. Specimens received from Des Moines were abundantly parasitized with *Pteromalus puparum*, and this species, with the *Apanteles glomeratus* and the epidemic disease that occasionally sweeps them away, certainly conspire to assist greatly in the reduction of damage from this widespread pest.

Specimens of the larvæ of the Army Worm (*Leucania unipuncta*) were received from Muscatine County with the information that they were injuring crops in a considerable area in that county, but as they were evidently full grown probably their injuries ceased almost immediately afterward, so that I have no further information as to injuries from them or of their being present in any other localities in that part of the State.

The Clover-seed Caterpillar (*Grapholitha interstinctana*) was again plentiful and caused a considerable loss in the clover crop. This species feeds readily on the leaves or in the crown of the plant and so does much injury aside from its destruction of the clover seed.

A common Pyralid moth related to the species of Crambus, the *Nomophila noctuella*, was extremely plentiful in grass land during early October, swarms of them being seen in all pastures and meadows. In a previous report I have called attention to this species as a probable serious pest in grasses, with habits similar to those of Crambus, and the observations this season on the numbers of the adults and their habits confirm my opinion that they have larval habits similar to Crambus and that they must cause a serious loss in pastures and meadows. Work upon other species has precluded any effort to trace the larval history the past season, and so far as I am aware nothing has been recorded with regard to it. It seems to me well deserving of investigation. The imagos of *Crambus exsiccatus*, a species which has heretofore been reported upon, with details of its life history, were plentiful this season, but not in such numbers as in some former years. Still they may be counted as among the very constant destructive species.

Edema albifrons was quite plentiful on Oak, and has been received from other localities, and would seem to be more than ordinarily destructive this season.

The larvæ of quite a number of Lepidoptera that are usually rather scarce or inconspicuous were during autumn quite abundant. Among these I may mention *Papilio cresphontes*, which, though usually very rare here, was taken in considerable numbers upon Prickly Ash. *Mamestra picta*, generally rare here (which may sound strange to entomologists in some other localities), was fairly common, though not to be counted a destructive species. *Actias luna* was quite common and many specimens were brought in by students. Also *Hyperchiria io*, very seldom seen in any great numbers, was found in considerable numbers. *Datana angusii*, as usual, was abundant, and *Grapta interrogationis* and *Vanessa antiopa* were conspicuous in their attacks. The common species, *Papilio turnus* and *Papilio asterias*, were more abundant than usual, and in some cases did damage to their respective food-plants.

At the meeting of the Association of Economic Entomologists held in August I reported some notes on the life histories of certain Jassi-

dæ which have been noted as specially destructive in this State, and which have a general distribution over the country. Since these have a general importance and some further details have been worked out since the presentation of that paper, I will venture to repeat briefly the facts as at present available.

A quite important step has been gained in the determination of the winter conditions of the strictly grass-feeding species, notably *Deltocephalus inimicus*, *D. debilis*, and *Diedrocephala mollipes*. These all deposit eggs in autumn in the leaves or stems of grass and the eggs remain in such situations over winter, hatching in spring.

The suggestion made in my report for 1889 (Bulletin 22, Div. Ent., U. S. Dept. Agriculture) is therefore well founded, and the burning over of grass land in late fall or early spring, when the grass is dry enough to burn down to near the surface of the ground, should prove a most effective and inexpensive method of treatment for pastures and meadows to reduce the numbers of these pests.

The life histories of the most common and abundant species may now be summarized as follows:

Deltocephalus inimicus.—Larvæ hatch from eggs deposited in fall, the larvæ appearing when fairly warm weather begins—ordinarily in April. The larvæ is at first light colored, but after the first molt has a black lateral border, a character by means of which it can be readily separated from *debilis*. These larvæ mature by the latter part of June, and imagos are plentiful during the last of June and fore part of July, becoming scarce again the latter part of that month, but depositing eggs which hatch in July and early August, and larvæ are very plentiful during early August and mature during the latter part of that month and early in September. This brood deposits eggs which remain over winter, though some of the earlier deposited eggs probably hatch in the fall and produce a late brood of larvæ, some of which seem to mature, and this probably accounts for the numerous individuals sometimes to be seen on warm days in late autumn and early winter. These seem to all perish before spring and probably without depositing any eggs. There is naturally a considerable amount of irregularity in the first appearance of adults and the time of egg deposition, but as these broods observed in the field have been paralleled with laboratory breedings there can remain little doubt as to the normal number and the time at which the bulk of the broods appear.

Deltocephalus debilis has practically the same life history, except that the broods appear about two weeks earlier, so that some adults will be found at the time the majority of *inimicus* are nearly grown larvæ. This makes it possible to use the tar pan at the time when the greatest numbers may be secured, which for most seasons will be at the time of the appearance of larvæ of both species, in late May and early June, again in early July, and a third time, if necessary, late in July or early in August. Of course applications will be made with reference to times

when larvæ or adults are noticed as hopping abundantly, and it seems from results of this season's work that the greatest numbers of hoppers are captured in the afternoons of warm days, with little or no wind, the hoppers seeming to jump best between 3 and 6 p. m.

Further tests of the tar pan have confirmed its value in destroying these pests, and a field test made with the coöperation of the farm department of the Experiment Station, and reported in full in Bulletin 19, Iowa Experiment Station, has shown that its use will practically enable the farmer to keep a larger number of cattle, sheep, or other animals upon grass land. In the experiment referred to, the result showed a gain of 68 per cent, but inasmuch as the experimental plat lay alongside other grass land and was subject to invasion from this, it seems to me that by a continued use of the treatment and over whole pastures, so as to preclude migration of insects from adjacent areas, we would get a still better result, and while it is perhaps too much to hope to get an increase sufficient to double the number of animals pastured on an ordinary field, I should hope to secure some such proportion, at least, if other destructive insects were also kept within bounds.

Another very widespread and destructive species is the *Diedrocephala mollipes*, and this has been the subject of a thesis study by Mr. J. A. Rolfs, a senior student in entomology here this year. The main facts in its life history may be stated in brief in this connection. The eggs in fall are mostly deposited in the rank grass of low ground, the insects preferring low ground during dry weather, which usually prevails for a few weeks in autumn. The larvæ hatching in spring, during May or early June, become adult by the latter part of June or early July, and in ordinary seasons will largely migrate to higher ground and deposit eggs, so that the second brood of larvæ, which appears in September, for the most part will be found widely distributed on both high and low ground, and may cause great damage. These larvæ mature by early October, and the imagos will, many of them, move to low ground to deposit eggs. It is evident that the burning over of sloughs and swampy or low ground is very desirable in the treatment of this species.

Plant-lice have been very plentiful during the autumn months, a strong contrast to their scarcity during the early part of the season. I had hardly returned from the Rochester meeting, where I reported a scarcity of these insects, when they became very conspicuous in their abundance.

Myzus persicæ on wild plum trees was among the species most noticeable, but the injuries it caused were by no means so severe as occurs when it is abundant in the early part of the season and attacks the growing twigs and the fruit.

Aphis brassicæ was specially noticeable on Rape, where it caused a considerable amount of damage, rendering the crop unfit for feeding. It was quite numerously infested with parasites in late autumn.

Many other species were abundant, and especially during October hosts of individuals were seen migrating from their summer locations to the plants which support their winter eggs. On some of these observations were made, but they can best be included in a discussion of the species in detail when their full life histories are worked out.

Last year I made a trip for the Division to western Kansas to investigate a local outbreak of grasshoppers, a report of which, with the recommendations suggested, was published in INSECT LIFE, vol. IV, p. 49.

Naturally, I was interested to know the outcome for the present season and wrote to parties in Garden City and Lakin, asking for a statement as to the abundance and injuries and what steps, if any, were taken in destroying them. I received two letters, from which I extract the following:

GARDEN CITY, KANS., *August 20, 1892.*

DEAR SIR: The grasshopper has been quite bad in localities. I think, from reports, that it will do almost as much damage as last year in the aggregate. On a few farms the wheat was injured and oats entirely destroyed—probably not more than one-half crop at the best. Farmers report that the fly is not killing many of them. Machines were made for capturing them. Some report large numbers taken.

ANDREW SABINE.

LATER.—Since writing the within I have been making inquiries and find that the hopper has been destructive only in spots. Wheat has not been injured. Some fields of oats destroyed. In other places only a few acres would be destroyed. They are commencing to disappear. Some say that they are dying rapidly. I met no one who had looked for the cause of death. Toads were innumerable this year—so much so that "everybody" was talking about it. I think the damage this year will fall much below that of 1891.

A. S.

LAKIN, KANS., *August 7, 1892.*

* * * As to the number of hoppers I see very little difference from last year. By far the most damage has been done by *Melanoplus differentialis*. I send you some hoppers caught this morning; also some dead ones found on asparagus. You can judge from the stalks the effect that they have had on that. There is a little green growth on the bottom yet. Parasitic Tachinids have destroyed more than last year. As to fighting them very little has been done, and that in a half-hearted way. I cleaned them out of the orchard wherever I cultivated the ground early enough and solidly. Am satisfied that they can be caught on the alfalfa by hopper-dozers. We have had some trouble in getting pans made, but they are bound to work if taken in time.

These hoppers will be likely to stay and grow fat just so long as we give them a good breeding ground and plenty to eat. We had some cold wet weather last spring just as they were hatching, which checked them some, but they seem to have outgrown it. I find a good many young ones now.

J. W. LONGSTRETH.

Prof. H. OSBORN,
Ames, Iowa.

TESTS OF THE BOTRYTIS TENELLA ON LACHNOSTERNA.

During the spring we received from your office a tube of *Botrytis tenella* from France, with instructions to test it on Lachnosterna larvæ in this locality.

Four tests were made of the material, following the directions for preparing and applying that accompanied the tube. Two of these tests were made in the laboratory in small glass root cages and two of the tests were in outdoor plats.

In the first laboratory experiment, May 26, about twenty larvæ were treated, ten of which were inclosed in a root cage two and one-half by four feet deep, and ten in an outdoor plat. Examinations later showed no result.

At the same time a few treated larvæ were placed in a glass root cage, the earth in which had been sterilized by continued baking, and kept in the laboratory for the purpose of closer observation. One specimen included in this cage was found to be covered with a small cyst of earth filled with a mycelial growth and the larvæ itself was covered with a dense white growth of mycelia. Another grub in this same cage went on and pupated and showed no signs of being affected by its treatment nor from being in contact with the diseased larva.

On June 23d another test was made, both in laboratory and field. Twenty-three treated larvæ were inclosed in a glass root cage 24 by 36 by 3½ inches inside. This was filled with sterilized earth to within 6 inches of the top. The earth had been sterilized by heating in a hot air oven from six to eight hours at 70° to 90° C. These were examined August 28. Three live grubs were found and five beetles. A number of larvæ, with no signs of growth, were observed dead on the surface a few days after treatment, and it is probable that they had been slightly injured before or during collecting, as they were picked up in furrow after the plow. The outdoor experiment, as in the first case, gave no result.

It will be seen that the only successful inoculation was of a single larva in a laboratory cage, and this diseased larva did not communicate the disease to another in close proximity to it. The field experiments showed no result whatever, though it can not be said but that larvæ became affected and escaped our notice in later examinations and that the disease may appear hereafter.

The tubes evidently contain a small proportion of spores and a large proportion of starch, so that it is possible the larvæ did not all get an inoculation with spores.

ENTOMOLOGICAL NOTES FOR THE SEASON OF 1892.

By MARY E. MURTFELDT.

LETTER OF SUBMITTAL.

KIRKWOOD, MO., *November 2, 1892.*

SIR: I herewith submit such of my entomological notes for the past season as relate to species of economic importance, including accounts of a few species that have not hitherto been included in that category. I have been much interested in the study of several other species, also pernicious or beneficial, but as these have not yet reached full development, I beg to reserve my notes upon them until I shall be able to complete the record.

Respectfully,

MARY E. MURTFELDT.

DR. C. V. RILEY.
U. S. Entomologist.

MISCELLANEOUS MEMORANDA.

The climatic peculiarity of the past season throughout the Mississippi Valley was found in the excessive rainfall and the low temperature of the spring and early summer. That these conditions would produce a noticeable effect upon insect life can not be doubted. Wheat fields and corn lands that were inundated during April and a part of May, so far as I have been able to ascertain, entirely escaped attack from Chinch Bugs and Bill Bugs. I am also inclined to ascribe to the same cause the somewhat remarkable non-appearance of the Colorado Potato-beetle over a wide area of the country. So absolute was this disappearance that repeated and careful search in this locality for specimens upon which to test insecticides failed to reveal a single beetle or larva. I can not say, however, that the potato crop was the better for this immunity. The plants seemed sufficiently vigorous, but the tubers were few and small and the crop in Missouri almost a failure.

Another insect that seems to have mostly deserted this section of the country is the Grape Phylloxera. For two or three seasons I have not noticed any galls on the leaves of even the most susceptible varieties, and examinations of the roots of Delaware, Taylor, Catawba, and

Herbemont have shown them to be free, or almost free from the subterranean form of the pest. Such old vines of the above and other delicate varieties of the fruit as had been suffered to remain in some of the vineyards around Kirkwood, have, for the last two years, renewed their vigor and borne good crops.

Flea-beetles gave very little trouble where gardeners had been careful, during previous seasons, to eradicate such weeds as Lepidium and Arabis from the neighborhood of their vegetable beds, since it is in the leaves of these that *Phyllotreta sinuata* Steph., with us by far the most abundant and destructive species, chiefly breeds.

The Cabbage Curculio (*Ceutorhynchus rapæ* Gyll.) occasions much loss and annoyance to market gardeners in some parts of the State, by boring into the crown and roots of young cabbage and cauliflower plants, in many cases destroying 25 per cent of the plants in the hotbeds and just after they are set out. As this insect does not trouble the plants after the heads begin toform, I was at a loss to conjecture what became of it during the summer and autumn. From experiments conducted this year I am convinced that it returns to its original food plant, the wild Pepper-grass (*Lepidium virginicum*). I succeeded in obtaining young larvæ in stems of the latter plant in July, but as the plants did not thrive indoors I was unable to bring the insect through its transformations.

Disonycha collaris is establishing its title as a spinach pest, its perforations being seen during April and May in almost every leaf of that highly esteemed pot herb. As both beetles and larvæ drop to the ground upon the slightest disturbance of their food-plant they are seldom associated with their destructive work.

The foliage of roses in Kirkwood and vicinity suffered this summer from the attacks of all three of the species of sawfly larvæ described in vol. v, INSECT LIFE (p. 6), *Cladius pectinicornis* being very numerous and reducing the leaflets on some bushes to mere shreds. An infusion of white hellebore proved an effective remedy, but the necessity of applying it at intervals throughout the season adds materially to the labors of the rose-grower.

The Twelve-spotted Diabrotica appeared in countless numbers in flower gardens during September and October, and wrought ruin on the blossoms of dahlias, zinias, cosmos, and early chrysanthemums. To kill it on the flowers, or render them distasteful to it, involves the sacrifice of all the beauty of the latter, by spraying with the arsenites or kerosene emulsions. Where the insect breeds in such swarms I have not been able to discover. Certainly it was not in any of the corn fields around Kirkwood, for I uprooted a large number of plants in the immediate neighborhood of our flower garden without finding any trace of larvæ or pupæ. I think its native and favorite food-plant remains to be discovered. Another unmanageable pest, of which there is complaint is the the Corn Ear-worm (*Heliothis armiger*).

It shows a marked partiality for the sweet table varieties, of which it destroyed in the gardens around St. Louis between 25 and 30 per cent of the ears.

The Tineidæ as well as the larger Lepidoptera contribute their full quota of species injurious to growing vegetation, in addition to those that prey upon stored grain and household property. Among the former the Box-elder Gracilaria (*Gracilaria negundella*) was exceedingly abundant during the past season in this locality, the leaves of the favorite shade tree upon which it feeds being thickly spotted with its preliminary mines and having almost every lobe turned down to form the three-cornered tent, within which the larva feeds after its first molt. Many of the cocoonets of the latest brood were parasitized, however, and it may not another season prove so disfiguring to the trees.

ADDITIONAL INJURIOUS INSECTS.

The Osage Orange Pyralid

(*Loxostege macluræ* Riley.)

Among the insects that are to be recorded for the first time with "noxious species" the one named above has, in this section of the country, acquired especial prominence.

Its work was first observed upon the hedges of Kirkwood and vicinity in the autumn of 1890, where for a few yards in a place the twigs and branches appeared nearly denuded of foliage. Examination failed to reveal the author of the mischief, and it was attributed to some Orthopteron, especially to those of the Tree Cricket family. The following year its ravages were seen on all the hedges of the county, greatly impairing their beauty. Late in summer the pest was discovered, and the habits by which it had so long eluded my search brought to light. During the present year its work has been increasingly destructive, and unless concerted action is taken for its extermination the hedges of the Mississippi Valley will no longer be either ornamental or useful.

The depredator is a small, glassy, pale green caterpillar, more or less gregarious, especially during the first larval stages. It is the young of a rather inconspicuous Pyralid moth, new to this region, if not to science, which may be popularly described as follows:

Expanse of wings nearly seven-eighths inch, or 24^{mm}. Fore-wings satiny in texture, of a pale brownish-gray color, sometimes, when the insect is perfectly fresh, faintly tinged with green or roseate, and always crossed by three curving, wavy, interrupted, dusky lines; the outer margin back of the very short white fringes being also dark. Hind-wings similar in color to the fore-wings, but thinner, without the dark cross lines, but with dusky shadings on the lower edges. Body, brownish-gray above, satiny white beneath. Head narrow, with projecting, beak-like palpi, margined with white, very long tongue, large hemispherical eyes of a mottled, dark-brown color, and slender, tapering, threadlike antennæ three-fourths the length of the wings. The abdomen is very slender, and somewhat constricted or laterally compressed, with long terminal joint upturned. Legs long, of a glistening white color.

These moths emerge in spring from the first to the middle of May, and may be seen on warm evenings fluttering in great numbers about the hedges. They are not much attracted by lamplight, but occasionally one enters a lighted room. The eggs are laid on the under sides of the Osage Orange leaves in irregularly shaped masses of from twenty-five to fifty. They are circular, very flat, pale yellow, and each has a delicate semitransparent membranous border. Like those of certain other Pyralids, they overlap, fish-scale fashion, and as the embryo develops each egg displays two minute black marks or lines. The larvæ hatch in five or six days, and, unless disturbed, remain in a close cluster, feeding upon the parenchyma of the under side of the leaf, which surface they closely resemble in color. At the slightest jar they curl up and drop to the ground. In six days the first molt takes place, and, if they have not sooner exhausted their food supply and been forced to scatter, they now migrate in small companies to fresh leaves, which, in feeding, they begin to perforate. When not feeding they stretch themselves alongside the midrib and principal veins, where their translucent, pale green color and very slender form enable them to escape observation. As they approach maturity they become still more elusive, retiring from the leaves during the day and resting upon the inner twigs and stems, which their coloring at this period usually imitates. They spin considerable web upon the under sides of the leaves, and draw out the threads as they crawl back and forth from the stems to the leaves. In these webs and threads more or less of the castings are caught, and add to the disfigurement of the plant.

Larva.—The full-grown larva is from eight to nine-tenths of an inch long (20 to 24^{mm}) by about three-twentieths (4^{mm}) inch in diameter in the middle when crawling. It is somewhat contracted and broadened in repose. The form is subcylindrical, tapering slightly toward either end. The color at this stage is variable, in some specimens translucent pinkish, in others dull green, and again of the gray-brown shade of the twigs, always obscurely striped on the dorsum and sides with a darker shade of the ground color, and having a narrow, but distinct, ivory-white stigmatal band. Piliferous dots black, surrounded with a paler ring, largest just above stigmatal band; four in subdorsal spaces on eleventh segment being in the hollow of conspicuous crescents, convex toward the sides. Head narrower than thoracic joints; cordate, with rounded lobes of a pale brown color, with irregular stripes in a slightly darker shade, trophi fuscous. Legs and prolegs concolorous with general surface.

The cocoon in which the worm incloses itself for transformation is of irregular shape and fits the chrysalis very loosely. It is of a fine texture and pale pinkish or dingy white color. The summer broods change to chrysalis soon after inclosure, but the hibernating one remains in the larva form until late in winter. The chrysalis is from 12 to 14^{mm} long, very slender, with slight corrugations on the posterior edge of the segments, and of a bright brown color. The cocoons are formed, sometimes several together, among the webbed and fallen leaves on the surface of the ground. At this date (December 1) the hibernating larvæ are somewhat shrunken and all of an opaque yellowish-white color, on

which the fuscous dots, rings, and crescents are very prominent. I have learned of the presence of the insect in one or two counties besides St. Louis, and have reason to think it quite widely disseminated, although not so destructive to hedges in more sparsely settled localities as it is in the various suburbs of St. Louis. Thorough spraying with any of the arsenites will kill it, but the process needs frequent repetition during the season, and much pains must be taken to wet the inner as well as the outer leaves.

The principal enemy of this insect, in its own class, is the Spined Soldier-bug (*Podisus spinosus*), of whose larvæ and pupæ I found a large number at different times with their beaks inserted in the bodies of the wriggling larvæ. A few larvæ were also destroyed by the small Ichneumonid, which was kindly determined for me at the Department as *Bracon juglandis* Ashm.

The Blue-grass Worm.

(*Crambus teterrellus* Zinck.)

For two or three years the moths of this species have in this locality outnumbered all the other species of Crambids combined. In the day-time they would flutter up from the grass before us at every step and at night our lighted windows would be covered with them. About the first of August, when these moths were most abundant, I had occasion to dig up a bit of sod from the lawn, and upon examining it closely I found several galleries of fine white web, with sparse minglings of castings formed against and between the stems and blades of the grass. In each of these tubes was a minute, dingy white larva, then 4 or 5^{mm} in length. This piece of sod was carefully planted in a large rearing jar and watered, so that it might continue to grow. A day or two after this a considerable number—eighteen or twenty—of minute, salmon-colored eggs were found on a window-sill near a dead specimen of the moth above named. By means of a fine camel's hair brush these eggs were transferred to a glass tube containing several blades of grass, and in the course of two or three days about a dozen tiny larvæ, of a cream-white color, with brown heads, had hatched. Placing them upon growing grass, they soon began the formation of tubes or galleries similar to those taken out of doors, and as they continued to develop, it was plain that they were identical with the latter.

During the dry weather of August and September others were found on the lawn, where the grass had withered in small patches, and it was evident that to this species is due to a considerable degree the faded appearance and scanty growth of the blue grass during the latter part of summer.

The growth of the larvæ was very slow and seemingly out of all proportion to the amount of web tubing constructed. A single larva, not more than one-third of an inch long, seemed to require for its domicile

a gallery 2 or 2½ inches in length, and with a diameter two or three times in excess of its own. The upper part of this tube would be exceedingly diaphanous, but as it descended more and more of the brass was intermingled until at the base it became quite compact. During the day the larva rested quietly in this retreat, but at night it emerged and fed upon the freshest of the contiguous blades. So far as I could ascertain it seldom or never cut through the stalk or bored up or down through the heart of the plant.

The larvæ seemed to attain maturity from the middle to the last of September, after which they rested quietly for some time in their galleries, without inclosing themselves in more protective cocoons.

Being absent from home for four or five weeks, from early in October until the middle of November, my jars were overlooked in the watering process, and upon my return I found all the larvæ dead and dry. As the species was known to me, however, this was not so unfortunate as it might have been.

In the jar containing specimens collected at various ages from the lawn were the remains of two or three hymenopterous parasites and four cocoons of the characteristic form, color, and structure of *Meteorus*, closely resembling those of *M. hyphantriæ*.

I append more particular description of egg and larva.

Egg.—Obconical 0.5^{m} long, beautifully sculptured under the lens, with longitudinal ridges and finer cross lines, giving it a checkered appearance. Color, bright salmon pink.

Larva.—At first of a dingy cream white, minutely speckled with brown, with brown head.

At maturity 15^{mm} in length, by 2^{mm} in diameter, subcylindrical, slightly larger across thoracic segments.

Color dingy yellowish or greenish white, with dull green medio-dorsal stripe. The surface is much roughened with impressed lines, with conspicuous, raised corneous, fuscous plates, from each of which arises a long, coarse, tapering, golden-yellow hair. Head with protruding lobes and rugose surface, and of a dull whity brown color. Cervical shield inconspicuous, darker than the head.

Pupa not yet observed.

The moth is well known as one of the least conspicuous of the group of beautiful species to which it belongs. It expands about three-fourths inch, with a brownish-white body and hind-wings. Fore-wings grayish-white, streaked with pale brown, with two silvery gray shaded wavy lines crossing the outer third; just back of the fringes, which have a golden, metallic luster, is a row of seven small but distinct black dots.

LASIOPTERA SP? IN TWIGS OF HONEY LOCUST.

The work of the above Cecidomyiid was first noticed in the summer of 1891 on the shoots and new growth of the Honey Locust, a shade tree of considerable value with us, and during the past season it became more and more injurious and conspicuous. The irritation of the plant

tissue produced by this insect causes remarkable tumefaction and distortion of the twigs and scantiness and yellowing of the foliage, resulting in a complete checking of growth.

The perfect insect is a minute fly or gnat, expanding about $\frac{1}{8}$ inch, having a glossy black body and broad transparent fore-wings, with a rather strong marginal vein, and a faint, forked vein on the lower edge. These gnats emerge from their cells early in May and lay their eggs (which I have not so far been able to detect) on the succulent new growth of the tree into which the microscopic larvæ easily burrow and begin the formation of their cells, very shortly producing gall-like swellings and twisting of the stems. These cells, each about $\frac{1}{8}$ inch long, and oblong in shape, become, as the season advances, exceedingly compact, almost stony, and in some cases almost fill the shoots for a space of from 5 to 7 inches in length. They are placed longitudinally, and a cross-section of a twig one-fifth inch in diameter will often cut four or five, although they are seldom regularly arranged side by side. The larvæ attain their growth in July or August, and remain unchanged in their cells until the following spring. They are at this time from three to four millimeters in length by one in diameter, cylindrical, with segments well defined, of a bright salmon-pink color, with conspicuous "breast-bone" in dark brown.

The outlet to the surface is probably by the passage through which the larva worked its way within the stem, though in what way extended, to admit of the egress of the much larger pupa, I can not tell. At all events when ready to emerge the pupæ are protruded, sometimes singly, in other cases in clusters of three or four where the larval cells have coalesced, from minute orifices all along the stem, giving it quite a fringy appearance with the erect translucent white empty pupa cases.

Two species of parasites have been bred from these Lasioptera galls, and examinations of infested twigs within a few weeks discloses more larvæ of parasites than of the original gall-makers.

Diplosis sp? on Soft Maple.

This is a probably undescribed species, also a Cecidomyiid, which destroyed a considerable proportion of the very young leaves of Soft Maple in Kirkwood and vicinity early in the spring. The punctures of the insect caused a peculiar curling and shriveling of the leaves, and in every depression would be found a minute white larva not more than 2^{mm} in length and 0.5 in diameter across the anterior end, from whence it tapered slightly posteriorly.

The first brood of flies emerged in June from little flattened oval cocoonets spun against the surface of the leaves. A second brood appeared late in July rolling the edges and crinkling the centers of the more tender leaves, but was far less injurious to the appearance of the trees than the earlier one.

Still another Cecidomyiid, of which I did not obtain the fly, attacked the foliage of the sugar maples in Kirkwood, curling and producing a gall-like thickening of the edges of the leaves. The affected portions turned crimson and gave the foliage the appearance of being covered with long, slender, red worms.

My attention was not called to this insect until it was too late to learn its natural history or to attempt the use of any remedy.

SCARCITY OF PARASITES OF CODLING MOTH AND PLUM CURCULIO.

Having always had some misgivings that in the practice of spraying fruit trees with the arsenites, we were destroying our most valuable allies in our warfare with the above-named pests, I made it a point during the past season to ascertain what proportion of them were really parasited.

Infested fruit was collected from an unsprayed orchard at intervals throughout the season, and both Codling Moth and Curculio bred in considerable numbers with a result that 4 per cent of Curculios were parasited, and from about one hundred Codling Moth larvæ not a single fly appeared. As the deluge-like rains of the spring and early summer may have had something to do with this unexpected result, I propose to repeat it another year, and hope to make a more satisfactory report.

EXPERIMENTS IN APICULTURE, 1892.

By J. H. Larrabee.

LETTER OF SUBMITTAL.

Agricultural College, Mich., *November 17, 1892.*

Sir: I beg leave to submit herewith a report upon the experimental work in apiculture conducted at this place during the season of 1892. While the results obtained may vary with varying conditions, either more or less favorable than those under which these experiments have been conducted, yet it is hoped that some of the conclusions reached may prove of definite value to the important interest of apiculture.

Very respectfully,

J. H. Larrabee.

C. V. Riley,
U. S. Entomologist.

During the season of 1892 the branch station for experimenting in bee culture at the Michigan Agricultural College was continued at the expense of the U. S. Department of Agriculture, Division of Entomology, and of the Michigan State Experiment Station.

An effort was made to undertake a line of experiments closely connected with the practical work of the apiary. While all of the experiments undertaken have not given results of practical value, some have. Especially gratifying are the results obtained in the experiments upon the subject of wax secretion and the evaporation of honey, for the reason that they were nearly free from those elements of uncertainty that must necessarily enter into nearly all experimental work in the apiary, such as season and condition of bees.

When the bees were taken from the cellar, on April 18, they were in rather poor condition, due doubtless to the dampness of the cellar and the character and amount of the stores. The loss during the winter and spring was about one-third of the number placed in the cellar.

In May and June the bees of the whole apiary were transferred from the old hives into modern dovetailed hives, and from the old reversible frames, of three distinct sizes, to the new, wide, thick, top-bar frames of the Langstroth size. In this operation all drone comb or other imper-

fect combs were rejected and rendered into wax. By this change the apiary was placed upon a modern footing, the hives made uniform, the operations and manipulations of the apiary rendered more rapid, and its beauty and value increased.

The spring was very backward and rainy. During fruit bloom the bees flew but little, and their influence upon the fertilization of the flowers of our fruits is seen in the almost complete failure in this vicinity of all tree fruits and others largely dependent upon the bees for the dissemination of pollen. As the rainy, cloudy weather did not cease until about the first of July, the early part of the clover bloom was lost to the bees. No supers were put on until July 8, and at that time strong colonies were swarming, with almost no honey in the hives. All of the white surplus was taken from Basswood, which yielded well. July 25 the season for white honey closed. A little surplus of late honey was gathered during August, and the bees filled up the hives well for winter. A yield of about 25 pounds of surplus per colony was obtained, and there are now in the apiary fifty-five colonies in excellent condition for winter.

BREEDING.

During the year 1891 the apiary was entirely requeened, only a few old queens being reserved for breeding. This season the opportunity was taken to replace all those of the former year's rearing that had proven themselves inferior. A number of Carniolan queens were introduced, and queens bred from them. Added familiarity with the cross of the Carniolan bee with the yellow race increases my satisfaction with their valuable traits. They have proven themselves equally as desirable as either race in its purity, and they have some points of superiority.

A test was made of the claims advanced for the Tunisian or so-called "Punic" bees. During the early part of the season they exhibited no traits that would distinguish them from the native black bee, showing the same nervousness under manipulation. They build large numbers of queen cells, and do not cap their honey with that peculiar whiteness characteristic of the common black bee. After the close of the honey season they best showed their origin and distinctive peculiarities. Whenever attempts were made to handle them they became exceedingly angry. This trait of excessive irritability seems to be their most distinctive mark. As no point of superiority was discovered, their several manifest defects make them a race not to be recommended as desirable for introduction among our American bee-keepers.

REMOVING THE QUEEN TO PREVENT SWARMING.

As the bee-keeping industry develops and new methods and devices come into use, each tending to lower the price of the product, an increased tension is placed upon the apiarist in an effort to manage large num-

bers of colonies to increase his annual yield. The natural tendency of bees to increase by swarming and the care and attention occasioned thereby have given rise to various plans for its prevention or control. One of the best of these plans, yet one little used, is outlined in the following, the value of which, at the suggestion of Mr. Aikin, of Loveland, Colo., I undertook to test: Early in spring two colonies were selected, as nearly alike in strength as it was possible to get them. These were kept at the same strength, the amount of brood in the hives having been equalized several times. The harvest did not open until about July 6, and upon the 8th supers were given them. July 12, queen cells were found partly constructed in colony No. 1. The queen was removed, and four days and also eight days afterward all queen cells were destroyed. On July 25 (thirteen days after her removal) the queen was returned. This colony did not swarm at all. The other colony (No. 2) was allowed to work without interference, and it was not until July 21 that they swarmed. As the harvest from Linden was about closing, the swarm was returned and all queen cells destroyed in the hope that they would not attempt to swarm again before the close of the season. They did not swarm, yet it may be supposed that this interference with their instincts tended slightly to decrease their energy. The results in total amount of honey gathered are as follows: No. 1 gained in weight 37 pounds between July 6 and 25, and No. 2 gained 46 pounds during the same time.

If from the total gain of No. 2 we substract 5 pounds as the weight of brood it contained in excess of the brood in No. 1 on July 25, we still have 4 pounds as the amount of honey gathered by No. 2 greater than the amount gathered by No. 1. These colonies were both worked for comb honey with like treatment of supers.

This experiment is valuable testimony to prove that the removal of the queen to prevent swarming does somewhat affect the amount of honey gathered by the bees. The supers showed even a larger difference in the amount of honey stored in the sections for the reason that where the queen is absent the bees fill the brood chamber with honey. When the queen is returned this will to a greater or less extent be removed to the sections. Although the interference in this manner with the economy of the hive probably always reduces the amount of honey stored, yet because of the lessening in the labor and watching necessary during the swarming season, I deem it advisable to follow this method when any similar plan seems necessary.

WAX SECRETION.

To determine the amount of honey consumed by the bees in secreting one pound of wax, this experiment, first undertaken in 1891, was repeated this year. As the conditions were much more favorable, the results were very gratifying. There was entire absence of a natural honey flow, the weather was favorable, the colonies were of the same strength,

and in prosperous condition, they took the food rapidly and built comb readily. The result gives a less amount of honey as necessary to be fed the bees in order to have 1 pound of wax secreted than was obtained in this experiment last year. This was to be expected because of the more favorable and exact conditions. Two colonies were taken which I have designated as Nos. 1 and 2. No. 1 was given a virgin queen and no comb or honey. No. 2 was given a virgin queen and empty combs. It was noticed that the bees did not fly from either of these hives as vigorously as from the others of the apiary, and that No. 1 was the more quiet of the two. Twenty-four and a half pounds of food were given, and almost exactly 1 pound of wax was secreted by No. 1. By weighing the combs both before and after being melted and taking the difference, the amount of pollen was ascertained. In both colonies the young queens had begun to lay, having been fertilized during the ten days the experiment was in progress. I now feel confident that more careful work on the part of others who have undertaken to solve this question will give practically the same results as are summarized below:

Wax Secretion.

	Colony No. 1.				Colony No. 2.			
	Lbs	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*
Weight of bees	7	5			7	3		
Gross weight, Aug. 2, with bees			27	8			34	4
Gross weight, Aug. 12, with bees			42	10			56	8
Gross gain in weight 10 days			15	2			22	4
Feed given	24	8			24	8		
Minus honey extracted	12	8			20	8		
Leaves honey consumed	12				4			
Honey consumed by No. 1 in excess of No. 2: 12−4=8 pounds.								
Wax secreted by No. 1		15½						
Pollen in combs at close	1	8			2	..		
Honey, wax, and pollen removed (8 pounds honey consumed in secreting 15½ ounces of wax	14	15½			22	8		

PLANTING FOR HONEY.

There were in bloom at the station this season three acres of Sweet Clover (*Melilotus alba*) sown in June, 1891. It was sown upon rather poor clay soil, yet it made a fair growth last fall and came through the winter in good condition. It began to bloom July 8, and continued in bloom until the 20th of September. The period of greatest bloom and honey secretion was from July 20 to September 1. It grew rapidly and was very rank, reaching a height of about six feet. The amount of bloom was great and the bees were continually busy upon it, yet during the period from July 24 to August 10, while it was in full bloom and while all other natural sources were absent, no honey of any appreciable extent was gathered and the hive upon scale lost in weight. Probably some honey was obtained during the season from this sweet clover, but in such limited quantities as to make any estimate of the value of the plant as a honey producer impossible. At the present time the

ground is covered with brush, so that labor will be necessary in clearing the land before plowing can be done.

With the idea of obtaining an opinion of the value of Sweet Clover as a silage plant an alcohol barrel was filled with the cut stalks, solidly packed, and sealed air-tight. This was done on July 14, just as the clover was getting fairly into bloom and while the stalks were yet tender and nutritious. On September 23 the barrel was opened and the ensilage was fed. A horse that had previously eaten corn silage ate it very readily, but another horse and a cow that had never eaten silage would not touch it. Several experts upon the subject pronounced it excellent. There is no doubt but that it would be a very desirable plant for the purpose if the feeding value per acre could be made equal to that of corn. An estimate made from the amount cut for silage gave between 6 and 7 tons per acre. Although its feeding value may be much higher than that of corn, it is still doubtful if it will pay to use it for this purpose alone, from the above estimate.

In concluding these experiments in planting for honey carried on by Prof. Cook and now concluded for the present, I desire to say that no results have been obtained with any plant sown or planted for honey alone that will warrant the bee-keeper in expending money and labor in this direction. Bee-keepers have in the past spent much time and money in the effort to cultivate some plant for the honey the bees may obtain from its flowers. In no case coming under my observation have these efforts been a success and the practice has never been continued at a profit. Therefore let me caution all apiarists against spending money in the attempt to cultivate at a profit any flower for honey alone. Bee-keepers should cease these useless efforts and turn their attention more persistently to extending the area of all wild honey-producing plants and urging upon all the superiority of Alsike Clover and Japanese Buckwheat as farm crops and the Linden as a shade tree.

EVAPORATION OF HONEY.

Nectar of flowers taken into the stomach of the bee undergoes certain chemical changes before it is finally deposited as honey in the cells of the honeycomb. The recent analyses, by direction of the United States Government chemist and those instituted at the Michigan State Experiment Station, prove that there is no chemical change made in the honey by the bee after it is deposited in the comb. There, however, remains much water in this honey that must be evaporated by the heat of the hive and the current of air through the hive caused by the fanning of the bees. It is well known that this labor of evaporation and the room occupied by this thin honey interferes greatly with the rapid gathering of nectar. In this opinion I am confirmed by a study of many records of colonies placed upon scales during the honey flow. It is often desirable to extract all of the honey gathered from one species of honey plant before the flow from other sources begins and before the

former has ripened to the usual consistency of good honey. The property of granulation in honey is so troublesome that its prevention would be very desirable. The experiments in this line have plainly indicated that the "water of crystallization" can be easily expelled by a proper artificial heat and the product sealed, so as to preserve it in a liquid state for an indefinite time. For these reasons it was thought best to experiment in this direction with various forms of artificial heat in the effort to devise some cheap and sure method to assist the bees in this work. For this purpose there were constructed a series of six shallow pans 19 by 28 inches in size, with partitions 2 inches in height, open on alternate ends, similar to the partitions in a maple-sirup evaporator. These were arranged in a cabinet, one above the other, so that honey entering at the top was obliged to flow some 75 feet before passing out at the bottom. An oil stove was placed beneath the whole, and a pipe at the top caused a current of heated air to pass upward over the honey. The fumes of the stove were carried off by means of a second pipe, in order to avoid all danger of their injuring the flavor of the honey. Honey of average body with 10 per cent by weight of water added was reduced again to the normal condition by passing twice through the pans at a temperature of 120°, and about 100 pounds per day was evaporated at that temperature. Thin nectar, extracted from the hives very soon after being gathered, was evaporated to the thickness of good honey at about the same rate. This apparatus was kept in operation about ten days upon honey of various thickness and upon clear water with the above definite results. The flavor of the first honey was injured—probably by the first acid action of the honey upon the outer coating of the tin. Afterwards this was not as apparent. The color was also somewhat affected.

The heat of the sun was also tried for purposes of evaporation. A shallow pan 28 by 54 inches in size was filled 3 inches deep with thin honey. This was covered with glass 6 inches above the honey and left in the sun for four days, when about 5 per cent of moisture was evaporated. As the honey lies at rest the water rises to the top, somewhat aiding evaporation. The flavor and color are not affected as much as by the method of running through pans. In this way honey with 30 per cent, and even 40 per cent, of water added was evaporated to the consistency of very thick honey in three weeks' time, so thick that it has not at this date showed any signs of granulation. During favorable periods of sunshine a temperature of 165° was reached. By this method a tank 4 by 6 feet, with 6 inches of honey and weighing 1,300 pounds, should be evaporated 10 per cent, or from the consistency of freshly gathered honey to that of average body, during about two weeks in July or August.

The common method of exposing to the air in open vessels in the warm upper story of a building was also tested with honey to which 10, 20, 30, and 40 per cent of water had been added. That having 40

per cent added became strongly fermented in a week's time, while only a slight change had taken place in the 30 per cent dilution, and at the end of a month it tasted like a very poor quality of commercial extracted honey or like honey dew. The 20 per cent dilution was not nearly as bad, and the honey, with only 10 per cent of water added, was during the month returned to the consistency of very fair honey.

Nectar extracted two or three days after the combs were placed in the hives contained, during the dry weather of July and August, from 10 to 15 per cent of water above the amount always found in honey that has been sealed in the comb by the bees. This was determined by evaporating in test tubes in hot water.

Summary.—(1) The method at present promising best results for artificial evaporation is that by solar heat under glass well ventilated. A small portion of a greenhouse or forcing-house arranged for conserving the heat of the sun, and so located that honey could be run into the shallow vats directly from the mouth of the extractor and drawn off from the bottom of the vats into marketing receptacles, should give good practical results.

(2) Very thin honey or nectar will not sour as quickly as supposed by many, and may be safely kept during any period of cloudy weather we may have during the hot summer months.

(3) The method of exposing to air in a warm room can not be depended upon to ripen very thin honey, although it may be serviceable for evaporating a very small percentage of water.

(4) The method of evaporating by artificial heat of stove or furnace is expensive and troublesome, requiring constant watching and care and not giving as good results as had been hoped for.

(5) The possibilities in the line of evaporating honey for the purpose of increasing the yield and preventing granulation are very great. A series of experiments to determine the increase in production by extracting freshly gathered honey would be next in order and value. When the utility of this method is fully demonstrated supers with fixed frames and extractors holding whole cases will be used and other apparatus conformable to the needs of the new system.

FEEDING BACK.

Feeding back extracted honey to secure the completion of unfinished sections at the close of the harvest is practiced by some apiarists, but with varying financial success. Extracted honey can be transported long distances with much greater safety than can comb honey. For this reason it has been thought it might be profitable to feed bees extracted honey costing 7 or 8 cents per pound to produce comb honey selling at 13 to 15 cents, locating the apiary designed for this purpose near a large city or other favorable market. With the idea of adding light upon this subject, extracted honey was fed to a number of colonies under the following conditions: The hives were contracted and the

queens kept in the brood apartment by means of excluding zinc. Five colonies were given two crates each of unfinished sections, the sections of the whole weighing 113 pounds. Three hundred and thirty-eight pounds of honey were fed these five colonies during twelve days. The honey was thinned with 12 per cent of water and warmed before feeding. The amount of finished honey obtained was 367 pounds, or a gain of 254 pounds by feeding 338 pounds of honey. The hives were weighed both before and after the honey was fed, and a gain of 36 pounds during the feeding recorded for the five hives. The following gives the results from a financial view:

254 pounds comb honey by feeding, at 14 cents	$35.56
36 pounds stored in hives, at 8 cents	2.88
	38.44
Minus value of 338 pounds fed, at 8 cents	27.04
Profit as pay for labor, etc.	11.40

Two colonies were given crates of sections with full sheets of foundation and were fed extracted honey, under the same conditions as the five colonies above:

	Pounds.
Amount of honey fed each colony	66½
Colony No. 1, finished comb honey	41¼
Colony No. 1, gain in weight of hive	9
Colony No. 2, finished comb honey	38
Colony No. 2, gain in weight of hive	7¼

Taking these two colonies as a basis, the following financial statement is made:

79¼ pounds comb honey, at 14 cents	$11.13
16¼ pounds honey stored in hives, at 8 cents	1.32
	12.45
Minus value of 133 pounds honey fed, at 8 cents	10.64
	$1.81

Deducting from this profit the value of the sections and foundation used, the actual profit, as pay for labor, etc., is, at most, nominal.

When this whole experiment was begun, and during the time it was in progress, no honey was gathered from the fields, but before the sealing was all accomplished the fall honey flow began, and for this reason the experiment was ended and the honey removed sooner than would otherwise have been advisable.

The results obtained in this work or in any experimental work of a similar character might vary under more favorable or unfavorable conditions of environment, and a continuation in various seasons, and under other conditions, would alone give really reliable results. The above trials are, however, very encouraging, and longer and varied work in this line is desirable.

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